

CHOCOLATE, COCOA, AND CONFECTIONERY:

SCIENCE AND TECHNOLOGY
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 - Lodders Croklaan, Wormerveer, Holland
 - Lodders Croklaan, Burgess Hill, England
 - Sais, Zurich, Switzerland
 - Sorbitol-Fructose:
Roquette Frères, Le Kremlin, France

Chocolate Bars and Covered Confectionery

PRODUCTION METHODS

The methods of manufacture of bulk chocolate have been described and there are certain well-defined processes for using chocolate to produce a variety of confections. These are summarized in the following.

Molding

This is the casting of liquid chocolate into molds (metal or plastic) followed by cooling and demolding. The finished chocolate may be a solid block, a hollow shell, or a shell filled with a confectionery material such as fondant, fudge, or soft caramel.

Enrobing

This is the mechanical method of coating confectionery centers with chocolate by putting them through a curtain of liquid chocolate followed by cooling.

Under this heading, hand covering and fork dipping may be mentioned. The former is the traditional method of coating centers by immersion in tempered liquid chocolate, removal by hand, usually one finger, although most of the hand is covered in chocolate, and then depositing on a glossy surface. The finger is detached from the liquid chocolate in such a way as to leave a decorative twirl. This is a highly skilled process, though not entirely hygienic.

Fork dipping avoids the immersion of the hand in the chocolate by the use of a thin pronged fork. The result is not quite so good in appearance.

Panning

This process, sometimes called the Volvo process, employs a rotating pan in which the centers rotate and cascade over one another. The chocolate is applied by hand or spray during rotation and is set by cooling air applied to the pan as it revolves. In this manner, layers of chocolate are built up around the center to any desired thickness and the shape of the final article approximates that of the center and is quite smooth. A polish or glaze is usually applied to this type of chocolate unit.

Tempering

This process is necessary as a preliminary to all the other chocolate processes. It ensures that the cocoa butter constituent is seeded and that the chocolate will set in a stable condition with a good permanent color and gloss.

OTHER CHOCOLATE PROCESSES

Chocolate Drops (Chips)

Chocolate drops or chips are made in very large quantities. They are sold in small bags for household use and in bulk for inclusion in cookies and other flour confectionery products.

Viscous chocolate, properly tempered, is deposited continuously from a battery of small nozzles onto a moving metal belt. The belt passes through a cooler and, after setting, the drops are discharged either directly into bulk packages or to a bag packaging line.

A necessary precaution with bulk packing is to see that the drops are completely cooled. If they are not, latent heat evolved in the bulk pack will raise the temperature of the drops well above ambient and ultimately severe fat bloom will form.

Drops are produced usually in small pyramid shapes but also may be deposited as small flat domes. These can be coated with colored nonpareils before the chocolate is set. Packed in attractive colored transparent bags, they make a popular children's product.

Roller Depositing

This production system has been designed for the manufacture of small solid articles using chocolate or other fat-based compounds. The

articles may be "lentil" centers, coffee beans, small eggs, balls, and so on, and they are formed in a pair of stainless-steel rollers in which the two halves of the article have been engraved.

The hollow rollers are equipped with a special coolant circulation system. This cools the rollers in such a way that when the liquid-tempered mass is fed between them, it forms a partly cooled continuous belt containing the shaped articles. This continuous belt is then passed through a cooling tunnel for the final cooling process. The cooling tunnel length can be designed to suit requirements, that is, if space is a problem, then a multipass cooler can be arranged that will reduce the length of the cooling tunnel.

After cooling, the web is transferred by conveyor to a rotating perforated drum. The speed of rotation and the angle of inclination of the drum are adjusted to separate the shaped articles from the flanges connecting the articles during forming. This process also smooths the surfaces for further processing, such as sugar or chocolate panning or polishing. The pieces passing the drum perforations are reprocessed.

The capacity of the roller line will depend on the width of the rollers and the number of pairs installed and can vary between 275 and 1,300 lb per hour.

Design of the roller assembly facilitates complete replacement and change of product (Figs. 7.1 and 7.2).

Aerated Chocolate

Aerated chocolate in bar or tablet form has been a very popular product for many years. The basic method of preparation is to subject well-beaten tempered chocolate to vacuum. The small bubbles will expand, producing a cellular product, and in this form it must be set by cooling. If the vacuum is released while the chocolate is still warm, the aeration will collapse.

A similar product may be made by mixing chocolate with carbon dioxide under pressure. Under these conditions, the gas is partially soluble in cocoa butter.

This chocolate may be released through nozzles to normal atmospheric pressure whereupon a cellular product, very similar to that formed by vacuum, is produced.

A third method relies on the addition of certain fatty substances and vigorous mixing. This gives a fine aeration that is not prone to collapse under normal chocolate handling processes.

Chocolate Flake or Bark

"Flake" is the trade name of a very popular English chocolate bar, but similar chocolate pieces are sold in Europe and in the United States. The idea of this form of bar arose from the physical condition of chocolate paste as it came from the refiner rolls, but because it is produced at considerable speed when making normal chocolate, it is broken into many small flakes. If the roll speed is reduced, the film on the roll surface can be removed in a continuous sheet and, depending on the angle of the scraper blade, can be collected as a wrinkled, partially compressed bar of a length equal to the width of the roll.

The width of the bar, or the quantity scraped from the roll, can be mechanically controlled by intermittent stopping and starting of the roll, and a take-off device, also mechanical, removes the bar from the scraper blade in unison with the halting of the roll. The length of the separate bars is controlled by means of a small sharp protrusion at intervals along the scraper blade.

Refiner paste for flake has a higher fat content than that for chocolate manufacture (usually about 31 percent) and is subjected to a certain amount of physical kneading.

Another method of getting the paste into a suitable condition for flaking is to add a small amount of water, which must be very adequately distributed through the chocolate.

During the kneading process, some cooling of the mass is necessary to temper the chocolate and to produce a stable cocoa butter seed. In this condition, at about 30 to 32°C (86 to 90°F) for milk chocolate, it is fed to the flaking rolls, and after producing the paste in bar form, it is transferred automatically from the scraper to a tunnel cooler where it is set solid in its crinkled form.

The pasting process and the slightly higher fat content than is normal for refiner paste ensures greater rigidity in the finished bar, which, because of its structure, is somewhat fragile. It also has a low weight for its bulk—a useful sales point.

Of recent years, this chocolate bar has achieved additional popularity as a sweet to be served with ice cream. It has also been marketed as a thinly chocolate covered bar, which gives the flake more rigidity.

A diagram of the mechanical principle of flake manufacture is given in Fig. 7-3.

There are alternative methods of transferring the flake scraped from the rolls. One uses a grab device that not only does the transfer but slightly compresses the flake. Another uses a system where the

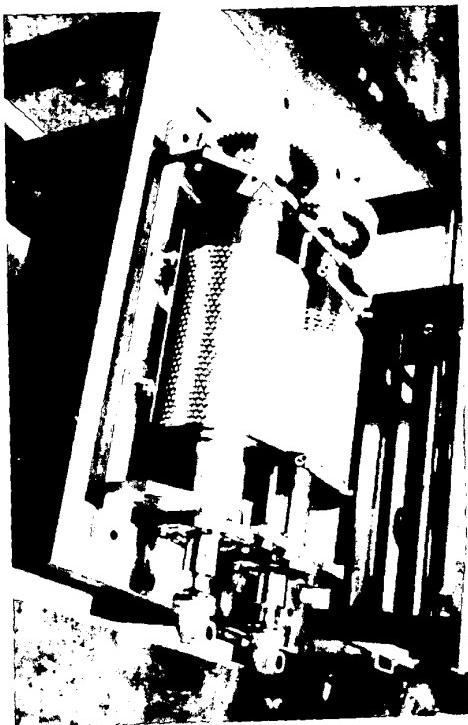


Fig. 7.1. Roller Depositing Machine

Aasted Mikrovert, Bygmarken, Denmark

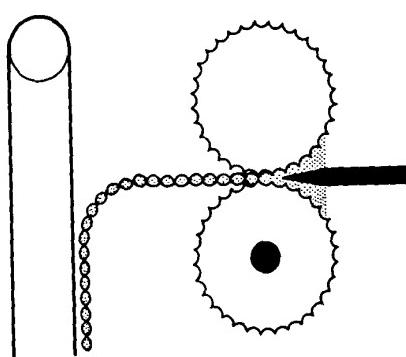


Fig. 7.2. Principle of Operation of the Roller Depositing Machine

Aasted Mikrovert, Bygmarken, Denmark

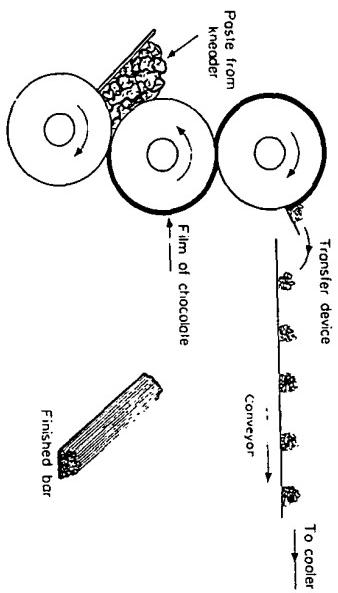


Fig. 7.3. Manufacture of Chocolate "Flake"

take-off plate slopes downward intermittently and pushes the flake bars off onto the cooler conveyor.

Chocolate Vermicelli or Streusel

Vermicelli is derived from the Italian, meaning "little worms," which it resembles during manufacture. This chocolate product was very popular at one time for coating truffles and is probably used more today for flour products than for chocolates.

Chocolate vermicelli is usually manufactured by the principle of extrusion through a perforated plate. The plate is fed with chocolate paste by a worm and rotating blade as in a mincer or by rollers rotating under pressure on the top of the plate. To produce vermicelli from pure chocolate is not easy as the paste has to be tempered to obtain the correct texture, and to maintain it in this condition in the extruder requires careful cooling control to prevent frictional heat from destroying the temper. This is helped by rapid transfer of the chocolate paste through the perforated plate, and to assist this, the holes are drilled with recesses (Fig. 7.4). In this way, the strength of the plate is maintained against the pressure of the paste, but friction during passage is reduced.

A recent machine by Lloveras S.A. uses a thin section sieve supported by crossbars. The paste is pressed through the perforations by Teflon rollers, and very little frictional heat is developed and there is negligible buildup on the rollers. The paste must be fed

consistently and in keeping with the optimum throughput of the extruder. Cooling must be provided immediately below the sieve so that the vermicelli strands are rapidly set and retain some rigidity by the time they reach the conveyor belt. Otherwise, the strands will curl and solidify in the tunnel cooler, making it difficult to break them up during panning.

The extruded paste is carried away on a belt for cooling, and emerges as a series of strands about 6 to 9 in. long. This is transferred to a confit pan and on rotation is broken into pieces ranging from $\frac{1}{8}$ in. to $\frac{1}{4}$ in., after which it is glazed with syrup. To give richer shades, the syrup may be colored with a "permitted" food color.

An easier method of producing vermicelli from chocolate is to mix about 6 percent of water with the chocolate paste before extrusion and this gives a suitable texture that is permanent irrespective of changes of temperature in the extruder.

The vermicelli produced, however, requires some drying, and the final texture is inferior to that of the pure chocolate material.

A third method of manufacture that gives a product suitable for flour confectionery where long shelf life is not required uses a plastic vegetable fat. The manufacture of the paste is similar to that described under "Coatings," with cocoa, sugar, and vegetable fat (and milk powder for light colors), a vegetable fat being chosen that has a pasty consistency at 31 to 32°C (88 to 90°F), but which does not have a complete melting point above 40°C (104°F). This paste can be extruded over a fairly wide range of temperature, but even after glazing, may be susceptible to the development of fat bloom.

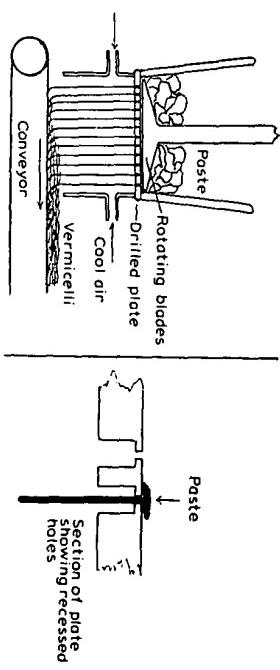


Fig. 7.4. Chocolate Vermicelli Manufacture

Laminated Chocolate

Tempered chocolate may be laminated by means of rollers and, while in a plastic condition, can be cut into bars or pieces. Laminations consist of dark, milk, or white chocolate.

Chocolate Tempering

It has already been noted that cocoa butter exists in a number of polymorphic forms and the nature of the crystalline form depends on the method of cooling the liquid fat.

If chocolate is solidified from the liquid state without any attention to seeding of the liquid cocoa butter constituent or to the method of cooling, it will be granular in texture and of poor color or blotchy in appearance.

To obtain chocolate tablets or covered confectionery of good texture, color, and in a stable condition such that bloom will not develop on the surface on storage, good tempering and correct cooling are essential.

The process of tempering consists of cooling down the chocolate with continuous mixing to produce cocoa butter seed crystals and distributing these throughout the mass of liquid chocolate.

Originally, with hand processes, this was carried out by turning over the chocolate repeatedly on a marble slab with a flexible pallet knife. This chocolate was then transferred to a small covering bowl that was warmed from underneath and could be topped with unseeded chocolate from time to time, and this well mixed in. The slab process is still used for introducing the first seed into small enrobers such as are employed in some retail establishments.

On a still smaller scale, a bowl of chocolate containing about 4 to 6 lb of chocolate is the starting point. This chocolate, if taken from a storage tank, will be at about 45°C (113°F) and it is preferable to cool this to about 35 to 38°C (95 to 100°F) before starting the tempering procedure.

About one-third of this chocolate is mixed on the marble slab until it thickens, taking care that lumps are not formed by repeatedly scraping from the outside to the center.

The thickened chocolate is then returned to the bowl and mixed thoroughly with the contents of the bowl. The mixture is then fully tempered. A skilled operator can tell quickly whether the chocolate is tempered by applying a small amount to the lips. A very small sample spread on a piece of foil and placed in a cooler should set

rapidly. A thermometer is a useful guide and the final temperature should be about 31°C (88–89°F), and a degree or so lower for milk chocolate.

A warning: use the thermometer only as a final check. The essence of hand tempering is visual judgment of the condition of the mixed chocolate on the slab.

With mechanical and large-scale tempering, temperature control is employed but visual checks are always useful. The thermometer, described later, is a precise instrument for determining exactly the degree of temper.

Hand covering and fork dipping require skill and practice but correctly done produce very attractive chocolates with good gloss and shelf life.

There is an ever-increasing number of small retail shops that use these methods. Illustrated books giving details with formulations are available (Wilton, 1983).

Machine Tempering The simplest and first large-scale temperers to be constructed were cylindrical steel tanks, water jacketed and provided with an internal scraper mixer (Fig. 7.5). Water is circulated through the jacket at 13 to 15°C (55 to 60°F) and the action of the stirrer is to sweep the liquid chocolate over the cool surface, thereby forming cocoa butter seed and distributing it through the liquid mass.

The scraper must be in intimate contact with the interior surface of the kettle to avoid building up a layer of overcooled chocolate that will contain unstable cocoa butter seed.

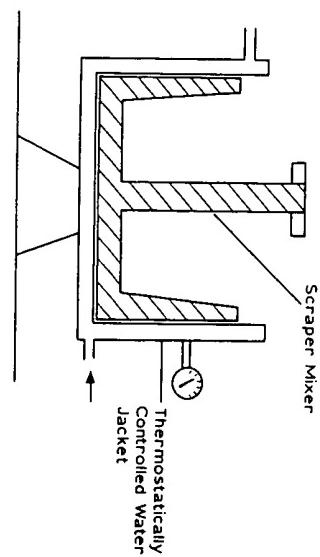


Fig. 7.5. Tempering Kettle

The temperature of the chocolate from the storage tank is steadily reduced from about 46 to 49°C (115 to 120°F) to about 28 to 29°C (83 to 85°F) for dark chocolate or about 1°C lower for milk chocolate because of the milk fat present.

At this temperature, the chocolate should have sufficient cocoa butter seed in stable form to ensure that the chocolate after cooling will also contain stable forms of cocoa butter. Moderate forms of cooling are essential (see later).

[Note: In Chapter 3, on cocoa butter, it was pointed out the unstable crystal forms have melting points of

γ 17°C (63°F), α 21 to 24°C (70 to 75°F), β' 27 to 29°C (81 to 84°F):

therefore, during the kettle process described above, unstable forms should not be formed.]

During the seeding process, chocolate viscosity increases as the proportion of seed increases, therefore, it either must be used quickly or heated to remelt some of the seed.

With molding machines with high output, quick usage is possible and duplicate tempering kettles are often used, but for enrober use it is necessary to raise the temperature of the seeded mass to 32 to 33°C (90 to 92°F)—lower for milk chocolate (88 to 90°F, depending on milk fat content)—and this has the effect of decreasing viscosity while still retaining sufficient seed to allow the cocoa butter to set in a stable form.

Raising the temperature will also ensure that any unstable seed is melted. This is important for the enrobing process as enrobed units are more susceptible to fat-bloom formation than molded bars, which have a highly glossy compacted surface.

Tempering kettles are now usually supplied with thermostatically controlled water circulation, which considerably simplifies maintenance of the correct degree of temper. A second kettle that contains untempered chocolate at about 92 to 94°F (34°C) is useful to supply small quantities to the tempering kettle if the viscosity should become too great.

If this is done, care must be taken to see that it is adequately mixed in or streaks will appear on the enrobed pieces. This same kettle may supply an enrober by drip feeding chocolate to maintain correct viscosity and temper in the enrober tank.

Another method of tempering is to use solid chocolate shavings that are mixed into liquid chocolate at 32 to 33°C (90 to 92°F), and this avoids the cooling and reheating process. This is particularly useful for small confectionery manufacturers who buy their chocolate in

block form. It has one disadvantage in that sometimes the shavings are difficult to disperse or will aggregate, and lumps of chocolate traveling round a pipe system can cause serious trouble as, even if screens are provided, these may become blocked. It is worth noting that certain chocolate technologists advocate this method of tempering and even go the length of preparing their chocolate seed by cooling well-grained chocolate in very thin layers on an enrober band. They claim that the nature of this seed encourages the formation of a maximum of stable forms of cocoa butter in the chocolate.

Automatic Tempering Modern chocolate plants for molding, enrobing, or shell production with large outputs are provided with automatic temperers. These are constructed in the form of tubular or plate heat exchangers with each section controlled thermostatically. Chocolate is delivered from the storage tanks and is subjected to the cooling and warming cycles, as previously indicated.

An example of the plate type is the DMW temperer by Aasted International of Denmark. These heat exchangers have the advantage of large cooling surfaces with very efficient mixing and scraping of the surfaces. This produces a fine-grain, stable seed in the tempered chocolate. The principle of operation is described in Fig. 7.6.

The whole system is enclosed in a module with external controls and capacity may vary from 650 to 9,000 lb per hour.

Principle of Operation By means of a pump, the chocolate is transported through the temperer. Continuous scraping of the surfaces ensures moderate cooling without any shock treatment.

The temperer is equipped with up to seven cooling zones, each with electronic controllers set at the required temperature. The temperer operates fully automatically.

To prevent the tempering machine from freezing when stopped, all tempering elements may be circulated with hot water from a built-in hot water system.

Technical Description Consider Fig. 7.6. The built-in drive motor (1), drives over V-belts a strong worm gear (2). The main shaft (3) with its scrapers (4) is driven by this worm gear. The scrapers remove chocolate from the elements (5) which are water jacketed. The various tempering sections are equipped with digital electronic controllers, which, by means of probes (6) placed in the chocolate flow, control the solenoid valves (7). At (8) cooling water is intro-

temperature and at a sufficient water pressure. The required cooling temperature is set by a thermostatic water valve (12).

Compound Coatings

It should be mentioned here that the conditions for tempering and cooling of chocolate do not apply to compound coatings. Lauric fat coatings, for example, require other conditions, and these fats are not compatible with cocoa butter.

These factors are described in Chapter 6 on confectionery coatings.

Measurement of Degree of Temper

Well-tempered chocolate contains approximately 3 to 8 percent cocoa butter crystals.

It is necessary with large molding machines and enrobers to know quickly whether chocolate being used is properly tempered. Experienced chocolate workers can assess the degree of temper fairly well from touch and by setting a small sample on metal foil. Temperature recording gives some confirmation. However, the precise degree of temper needs rapid scientific confirmation if large machines are to work consistently.

One instrument developed to accomplish this is called the Tempermeter. It is based on the principle that under controlled conditions of cooling chocolate there is a relationship between the cooling curve and the degree of temper.

The instrument consists of a temperature recording probe that is immersed in the sample of chocolate contained in a narrow tube. The tube is immersed in ice water and the probe is connected to an automatic recorder that prints the temperature on a moving chart at equally spaced intervals of time. Thus, a cooling curve is formed and the shape and slope of the curve depend on the degree of temper. The curve is produced in about 4 min.

The latest instrument by Sollich uses a transparent inclinometer, which greatly facilitates the measurement of the slope of the cooling curve.

In sampling, it is essential that the chocolate be taken directly from the molding machine or enrober to fill the tempermeter tube. Figures 7.7, 7.8, and 7.9 show the instrument, typical cooling curves, and the inclinometer.

Apart from measuring the degree of temper of normal chocolate,

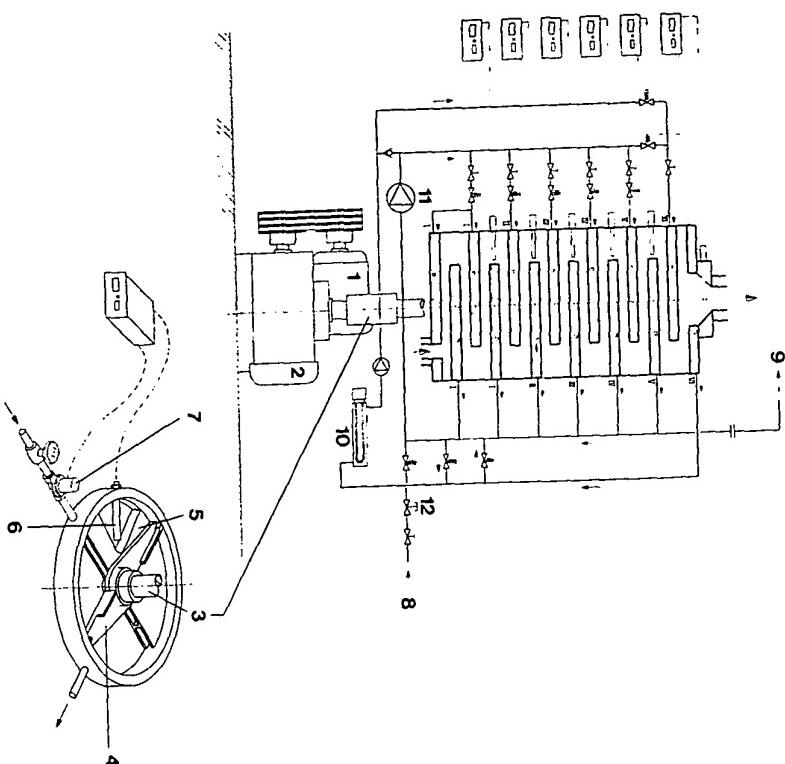


Fig. 7.6. DMW Tempperer

Aasted Mikrovert, Bygmarken, Denmark

duced through a thermostatic water valve, and at (9) is returned to the water cooler. In the latter section, cooling or reheating can take place as required.

A cooling water pump (11), and hot water supply (10), together with a thermostatic valve, forms part of the cooling water stabilization. The stabilizer ensures that the cooling water is supplied at a suitable

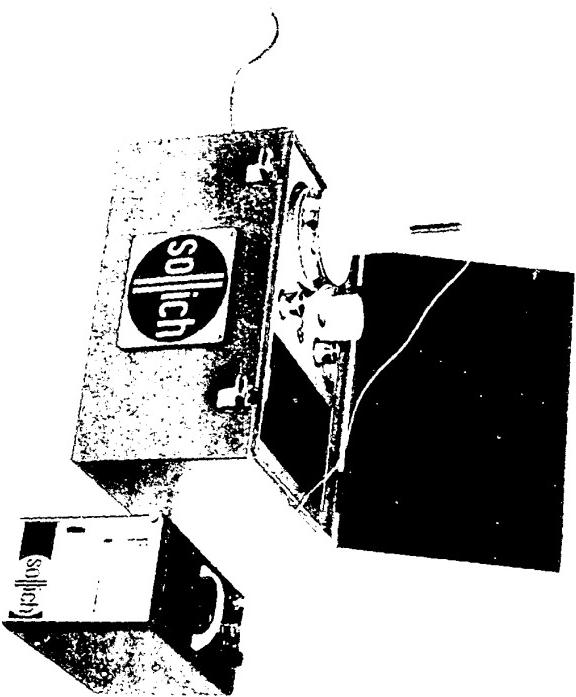
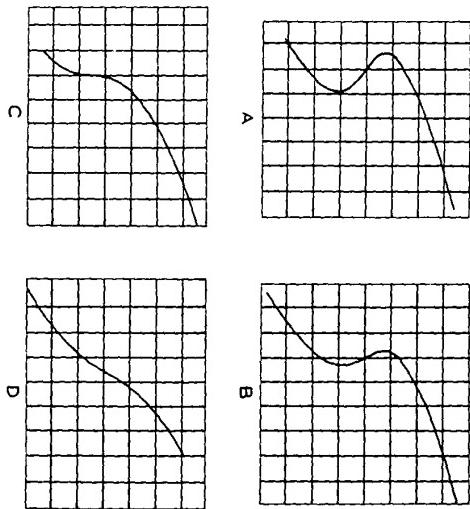
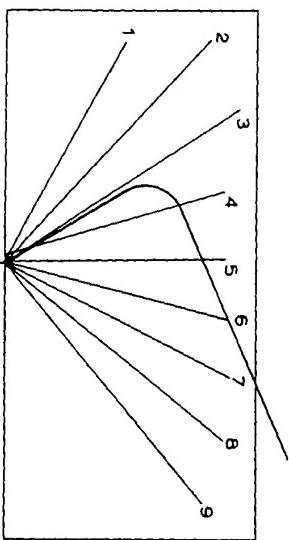


Fig. 7.7. Portable Control Unit for Determining the Degree of Temper in Chocolate

Söllrich KG, Bad Salzuflen, W. Germany

the instrument is useful in estimating the effects of additions to chocolate.

Fats claimed to be cocoa butter equivalents, which, in all chemical and most physical respects, are identical to cocoa butter, sometimes retard the tempering process when mixed in the chocolate. By taking samples from a tempering kettle at prescribed intervals and determining the degree of temper, this effect can be measured. Lecithin added to chocolate in amounts much above the normal of 0.5 percent will severely retard the tempering process. Occasionally, an error in dispensing in a continuous mixing process may produce this effect. Richardson (1986) has shown that the principle of the Temper-

Fig. 7.8. Representative Curves Produced by Tempermeter
A. Undertempered B. Slightly Undertempered
C. Correctly Tempered D. OvertemperedFig. 7.9. Illustration Showing the Use of "Inclinometer"
1. Very Undertempered 6. Very Slightly Overtempered
2. Undertempered 7. Slightly Overtempered
3. Slightly Undertempered 8. Overtempered
4. Very Slightly Undertempered 9. Much Overtempered
5. Correctly Tempered

meter may be computerized with a printout of the curves and ready assessment of the degree of temper.

CHOCOLATE MOLDING

Molding Chocolate Blocks or Bars

The chocolate may be mixed with nuts, raisins, small cookies, or small pieces of hard confectionery. This chocolate or chocolate mixture is deposited into molds and, after cooling, is knocked from the molds as solid pieces. These machines are, in principle, relatively simple but involve some complicated mechanical devices, especially the depositor. They consist of the temperer, the depositor, the mold cycle carrier, the cooling tunnel, and the packing belt. The temperer has already been described. The depositor has multiple valves that will take chocolate or a mixture with nuts, raisins, and other ingredients from a hopper and deliver a row of deposits of correct weight into the mold impressions.

The design of molds is an expert's job; although the general appearance of the finished block or bar may be decided by the sales staff, the exact design of the impression requires knowledge of the optimum angles for the mold sides and the type of embossing that will facilitate demolding and give a good appearance.

Certain companies are specialists in mold manufacture and must work closely with the chocolate manufacturers' engineers and pattern makers.

The following comments are relevant:

1. Steep angles at the sides of the mold impression obviously cause more difficulty with demolding. This problem may be emphasized if there is a slight flange where the mold impression joins the face of the mold. Milk chocolate products are more difficult to produce in these circumstances.
2. Areas of flat surfaces without embossing should be avoided. Force marks, which look like finger marks, may appear on these areas.
3. Do not have deep embossing. Intricate design causes problems with the occlusion of air bubbles and small particles of chocolate.

Metal molds were used originally and were carried on an endless chain. Depending on the size of the molded article, the mold frame contains many identical impressions, and many hundreds of these molds may be transported on the chain.

At the start of the cycle, a warm tunnel heats the molds to a temperature approaching that of tempered chocolate. The molds then receive deposits of chocolate and the whole chain and molds are subjected to violent vibration or tapping to distribute the chocolate evenly over the molds and to remove air bubbles from the bottom of the mold, which will be the face of the block when demolded. After this operation, the molds pass into the cooler. The design of coolers and the air conditions used for all types of chocolate plant are discussed elsewhere. At the end of the cooler, the molds are reversed and the molded blocks tapped out onto a conveyor belt that takes them to the wrapping machines. The empty molds return to the mold heater and then to the machine to receive the next deposit of chocolate.

Metal molds were once the only type available, but plastic molds are now in almost universal use.

Thermal conductivity, which is inferior to metal, was originally a problem when the molds were of very solid construction. Designs have been improved, and by means of special bracings, the mold impressions themselves are now sufficiently thin to give good heat transfer.

Plastic molds are considerably lighter in weight than metal molds and a recent development in this direction was the introduction by Aasted International of a carrierless molding plant. This new design eliminates the use of the heavy metal mold carrier. When using plastic molds, the physical load on chains, rails, and turning points is reduced substantially, with a consequent increase in the life of these units. In addition, the power rating for the motors is reduced, and energy consumption, both in the mold heater and the cooling chamber, is reduced to a minimum. This new mold is designed with guide pins on each end and a long hole in the middle for the insertion of the suspension pins. Only the guide pins from one side are required to turn the molds over when producing hollow articles or when conveying molds from one level to another.

The long hole in the middle—that is, the central suspension—provides a more efficient shaking of the mold. In addition, the noise level of the plant is considerably reduced by the elimination of any metal-to-metal contact.

Hollow Goods

Hollow chocolates include Easter eggs and rabbits, Santa Clauses, and the like. The molds are in two halves, usually hinged to open and close like an oyster. The requisite amount of tempered chocolate is deposited in one half of the mold, and the mold is closed and clamped or magnetically attached to a machine that rotates the mold through a variety of directions, thereby distributing the chocolate evenly on the inside of the mold. While rotating, the chocolate is partially cooled until it ceases to flow. The molds are then removed and setting is completed in a tunnel cooler, after which the molds are opened and the articles removed.

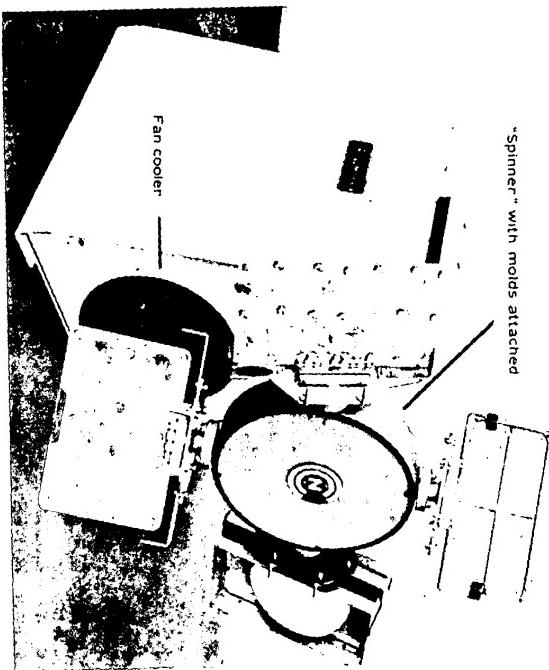


Fig. 7.10. Minispinner for Hollow Chocolate Articles

Collman GmbH, Lübeck, W. Germany

Fully mechanized equipment is available in which chocolate is deposited into the molds, followed by closure, complete cooling, and opening of the molds.

The chocolate must be well tempered but sufficiently fluid to flow evenly around the inside of the molds. There must be no delay between filling and placing on the spinner. Uneven chocolate will result in splitting of the finished article as a result of uneven contraction.

Figure 7.10 shows the principles of operation of the spinner.

Foiled Articles

It is possible to mold solid or hollow chocolate articles in printed foil that is pressed into the mold shape prior to depositing the chocolate. Hinged molds are used and the final article, in such shapes as Santa Claus or the Easter Rabbit covered with brightly colored foil, are very attractive.

Shell Forming Equipment

These are very complicated machines and are now fully automatic. Chocolate is deposited into molds and, by a reversal operation, a lining of liquid chocolate is left coating the inner surface of the mold. This is set by cooling and the hollow shell then receives a deposit of confectionery center followed by backing with more liquid chocolate. After cooling, the chocolates with centers are removed from the mold by reversing and tapping. See Fig. 7.11.

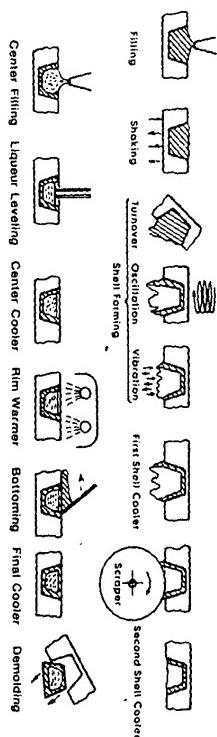


Fig. 7.11. Shell Plant Production Sequence
Note: Liqueur leveling applies to liqueur centers only.

Gehr. Binder, Bergneustadt, W. Germany

The original shell equipment made small shells for assortment units and these were usually filled with a liquid type of center at a temperature below the melting point of chocolate, and then backed with a deposit of liquid chocolate. A great deal of trouble was experienced with this type of assortment, from oozing of the center through imperfect seals between the shell and back and from fermentation of the center through the use of recipes with a low concentration syrup phase.

Shell equipment developed in recent years have been capable of receiving deposits of hot fondant into the chocolate shells, and this has meant very special design of the cooling section immediately before and after deposit of the fondant. This remarkable advance in technique has greatly increased the variety of confections that it is now possible to make on such equipment. Large fondant-cream-filled bars, as well as small assortment chocolates, can be made by this method and a still further spectacular development is the production of assorted-center-filled blocks. The chocolate shell is made by the same method but the indentations in the shell receive small deposits of different confections, such as fondant, fudge, soft caramel, Turkish delight, and coconut paste. These various centers are ejected in hot liquid form from multiple depositor nozzles fed from a series of hoppers. These hoppers are kept supplied from separate kettles where the different recipes are usually made batchwise. This equipment has eliminated much of the production of centers by the starch-deposition method.

In addition to the sheer engineering of these large machines, a profound knowledge of handling the chocolate and centers is required. This includes standardization of viscosity, control of tempering, the nature of the fat phase of the chocolate, and particularly the type of centers. When casting centers into starch some moisture loss occurs. In a chocolate shell this cannot occur and it is vital that the syrup phase concentration of the confection be maintained at a safe level.

A diagram of modern shell equipment is shown in Fig. 7.12. It is capable of depositing hot centers. The direction of flow of the molds is shown by the continuous dotted line.

Where depositing of hot centers such as fondant is involved, reduced cooling of the shell before deposit is necessary in addition to extra cooling after the deposit. By this means, the hot center will melt only a superficial layer of the chocolate on the inside of the shell.

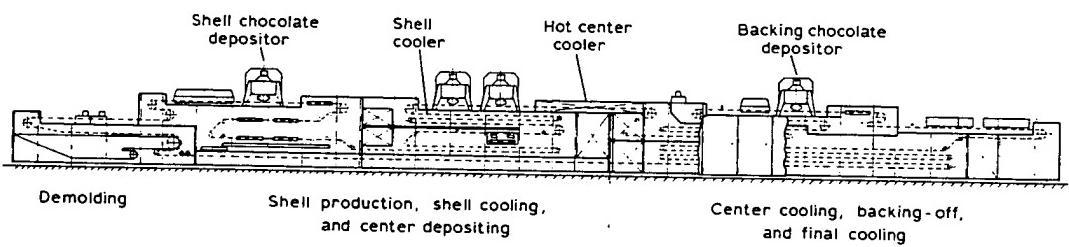


Fig. 7.12. Diagram of a Modern Shell Plant

Aasted Mikroverk, Bygmarken, Denmark

The Westal SCB Process

This process is for the production of filled items in one depositing sequence.

The basic principle of operation has been used for over fifty years by, notably, Cadbury and Toms of Denmark. The machine was developed and made commercially available in 1978 by Westal Ltd., now a division of Baker Perkins.

The principle of the process is the simultaneous depositing of liquid chocolate and confectionery into a mold. Deposits are shaken down into the mold impression and, after cooling, a complete shell with filling is formed.

Filled bars and double items may also be made, and multiple deposits of different chocolates and centers in the same mold are possible. A version is available for marbled chocolate and fillings.

Figures 7.13 and 7.14 show the method of formation of the separate units and the sequence of operations in the molding equipment. Discharge of the molded units can be on a continuous belt or on plaques.

The process is especially suitable for soft or semifluid centers but it is essential to ensure that the syrup phase concentration of 75 percent minimum is maintained. Where alcoholic liqueurs are permitted as ingredients, a reduced concentration is possible.

The equipment is compact, reliable, and economical of energy, labor, and space.

COMPOSITION OF CHOCOLATE FOR MOLDING

Chocolates made as previously described, either dark or milk, are suitable for molding, but by reason of the different methods of manufacture and inclusion of lecithin, fat contents are much lower than they were some years ago.

There has been a steady reduction in the total fat contents of all chocolates, whether for molding or enrobing purposes. With the higher cocoa butter contents that prevailed at one time, the contraction of the chocolate was considerable and simplified the demolding. With the lower fat contents, which have been obtained by the use of emulsifiers and the additional mechanical aids to reduce viscosity, the effect of contraction is minimal. Good-quality, finely ground chocolates with total fat contents down to 28 percent can now be produced and satisfactorily molded. Lower-quality chocolates with coarser particle size can be produced down to 25 percent. Particularly with milk chocolates, quality suffers with fat contents below 30 percent, the texture becoming pasty with a lack of snap.

Demolding of small chocolates from deep molds can be difficult with milk chocolate with high milk solids (25 percent including milk fat) and an improvement results from reducing the milk solids to 15 percent. If it is not required to call the confectionary block by a name that implies that the covering is whole milk chocolate, a proportion of nonfat milk or whey powder may be used.

The addition of rework may also cause demolding trouble due to the presence of soft fats in the centers used for the rework—such chocolate is best not used for chocolate shells. Dark chocolate with butter fat addition for antibloom purposes can present difficulty if the maximum of 4 percent is used. Molded surfaces are much less prone

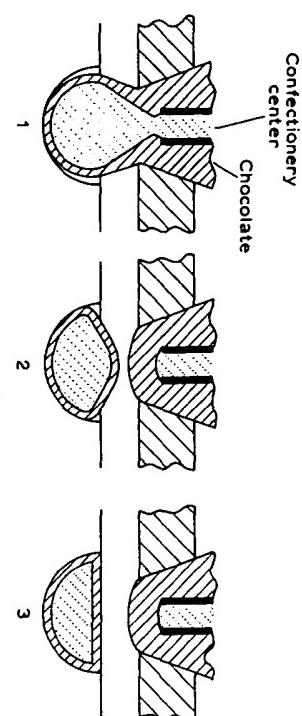


Fig. 7.13. Formation of Separate Units in a Molding Plant
Westal Company, Redditch, England

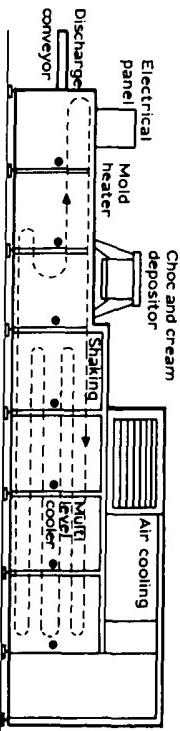


Fig. 7.14. Diagrammatic Sequence of Operations in a Molding Plant
Westal Company, Redditch, England

to bloom development than enrober-covered chocolates and generally antibloom additives are required only to prevent bloom on the backs of molded lines and the minimum effective addition of 2 percent is adequate.

Many chocolate blocks and bars contain nuts (hazels, almonds, brazils) either whole or chopped. Some contain raisins as well, which must be dry and firm or they will adhere to one another and cause thickening of the chocolate in the depositing hopper. Raisins are purchased in large cartons in a slightly compressed condition and it is common practice to dust lightly with fine sugar or maize starch when breaking up the blocks for use.

Other popular ingredients in chocolate blocks are small Rice Krispies or other cereals, and small pieces of boiled sugar, preferably aerated, to avoid a gritty texture when eating.

Some of these additions, particularly cookies, will absorb cocoa butter from the chocolate, and to avoid the use of excess cocoa butter, rapid mixing and depositing are desirable. Devices are in use for the continuous feeding of an ingredient into a stream of tempered chocolate. They are mixed in the recipe proportions and fed directly to the depositing hopper.

An extremely popular type of molded line is the wafer biscuit bar. These generally consist of a laminated wafer with a flavored fat-cream filling. The machinery for manufacture of these lines is complicated and the general principle is to fill a multiple-section mold with chocolate and to press wafer fingers into the sections. The excess chocolate is backed off by means of a roller or scraper.

MOLDING AND SHELL PLANT COOLERS

Problems arise in the cooling of chocolate in molds and shells that differ from those in enrobers. The following are important points.

Tablets

In the molding of tablets, blocks, and shells, good contraction is required to help the demolding process. That means good tempering and fairly rapid cooling, but the cooling is best achieved by high-velocity air rather than low temperatures so as to avoid the formation of unstable cocoa butter seed. In enrobing, rapid contraction is undesirable as it causes splitting of the chocolate covering, and possibly oozing from weak points in the covering.

Shells

After deposition of the chocolate and reversal of the mold, the liquid chocolate must be cooled without disturbing the chocolate. Therefore, high-velocity air should not be directed onto the chocolate initially.

The shell, being thin, will cool quickly even with moderate air flow, and if the cooling is too vigorous and uneven, distortion of the chocolate will occur. This is particularly noticeable with shells for filled bars or blocks and the distortion may result in the bars becoming loose in the molds and detached at the ends, which are bent upward. If this occurs and the center deposit is, for example, hot fondant, the shell may be softened and settle again in the mold. This will probably cause defacing of the embossings. Following this, when the backing chocolate is applied and cooled, contraction will occur and this can emphasize the distortion problems. Bent bars create packaging problems and result in breakage during packing.

GOOD MANUFACTURING PRACTICE

In all molding plants, efficiency depends on obtaining 100 percent ejection of units from the molds because, if some of the molds become blocked, they have to be removed from the cycle. The chocolate that has stuck to the mold must be removed by hand and the mold cleaned. With equipment for shells and filled articles, this can be a very expensive operation and the disposal of the rejected material poses another problem.

Good demolding depends on proper tempering of the chocolate, adequate and even cooling, and starting with clean molds. Good tempering will result in good contraction, but milk chocolate is more difficult to demold than dark chocolate because of the soft milk fat it contains; this applies particularly to small shell chocolates, for which it is often desirable to use a chocolate with reduced milk or milk fat content.

Mold cleaning is done periodically. Special washing equipment is used for this purpose.

High-pressure hot-water jets with some detergent are used, followed by a rinse, preferably with soft water, and hot-air drying. Care must be taken in the washing of plastic molds and information should be obtained from the manufacturers regarding suitable detergents.

CHOCOLATE ENROBING

Chocolate assortments, confectionery bars coated with chocolate, and chocolate cookies and cakes are all manufactured by the coating process known as chocolate enrobing. Reference has been made to hand covering, but the coating of chocolates by this process is reserved for the very expensive assortments mostly sold in exclusive shops.

The principle of the enrober may be summarized as follows: The confectionery centers to be covered with chocolate are placed on a conveyor belt—usually made of plastic-coated canvas. With small units for assortments, this is mainly done by hand, but with larger bars, mechanical placing is used, particularly if enrobing is preceded by cutting from a large slab or extrusion from a series of nozzles. From the canvas belt the centers are transferred to a wire net specially designed for enrobers, which first passes over a bottom-coating device. This part of the machine consists of a system of pumps or rollers that produce a shallow surge of tempered chocolate through the net, lifting the centers slightly and at the same time coating the bottoms. These bottom-coated units are transferred automatically to another belt, where the bottom chocolate is cooled by passing over a cold table, and from this to the main enrober net.

The prebottomed centers are carried on this net through a curtain of tempered chocolate, thereby coating the tops and sides as well as providing an additional thin coating on the bottoms. After emerging from the curtain, the covered chocolates are subjected to blowing by air from fans and to vibration of the net, both of which are adjustable, and are used to control the amount of chocolate remaining on the centers. From the enrober net, the chocolates are again transferred to a conveyor belt, which takes them to the cooler, but at the transfer an "antitailing" device consisting of a small-diameter spinning roller takes off the drips of chocolate at the ends and edges of the bars.

An antitailing device is also necessary at the discharge end of the prebottomer, or the tails formed will be partly solidified on the cooling slab and will be enlarged when passing through the enrober. Many enrobers are worked without prebottomers. This may be satisfactory for small centers, but it certainly is not for large bars. In the enrober machine, an upward surge of chocolate will provide some bottom coating, but with the heavier pieces, the vibration of the net will cause them to sink through the chocolate, resulting in very thin bottom coating. Very little protection thus is given, and subsequently

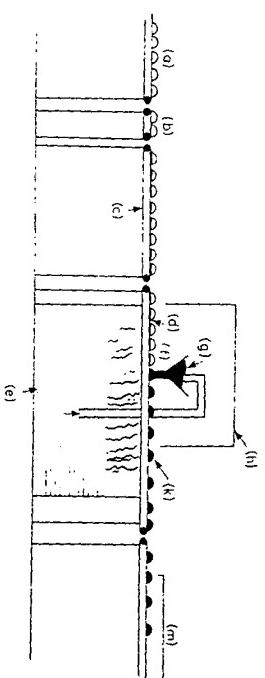


Fig. 7.15. Enrober System
 a. Conveyor-Uncovered Centers b. Bottom Coater
 c. Bottom Cooling Conveyor d. Enrober Net
 e. Tank of Tempered Chocolate f. Chocolate Curtain Supplied From Reservoir of Tempered Chocolate
 g. Reservoir of Tempered Chocolate h. Shield
 k. Covered Centers m. Cooler
 Decoating by hand or mechanically is carried out at position k. There are ingenious machines available for applying chocolate designs to the enrobed chocolates.

the center will dry out or pick up moisture, depending on the nature of the center and ambient conditions.

A diagram of the enrober system is shown in Fig. 7.15. Enrobers have, during the past fifty years, developed from small machines requiring a great deal of skilled attention and continuous adjustment to very big machines with automatic tempering of the chocolate. The original machines had a net width of 15 to 18 in., whereas modern machines may be 54 in. wide and use great quantities of chocolate. With the larger enrobers that are not automatically operated, a constant supply of tempered chocolate is necessary. This may be obtained from tempering kettles used to supply the enrober reservoir tank.

A skilled enrober worker is required to maintain the quantity of chocolate in the enrober tank at the right degree of temper to prevent overthickening or loss of seed by adjusting hot and cold water circulation. The same operator is required to keep the chocolate kettles filled with tempered chocolate, or, if the enrober tank is kept full enough, it can be supplied with cooled but untempered chocolate, with the tempering taking place in the enrober tank itself.

As a development of the last principle, drip feeding of the enrober tank with untempered chocolate equal in quantity to the chocolate

demand is done in some factories. From this description, it is readily understood that it takes skill to work an enrober efficiently and to maintain correct weights of chocolate on the center, at the same time keeping the chocolate properly tempered.

With the latest high-output enrobers, automatic tempering has been introduced. This is a complicated procedure as the enrobing process differs from molding in that a proportion of the tempered chocolate from the chocolate curtain returns to the enrober reservoir tank. This chocolate will increase in viscosity as a result of the continuous formation of more seed of cocoa butter crystals. It is necessary, therefore, to remelt these, either by returning the chocolate to the storage tank or by mixing it with untempered chocolate.

Automatic enrobing systems are described later.

Mechanical

Whether an enrober is fully automatic or hand controlled, it is necessary to have some understanding of the mechanical processes involved. The following is a brief summary of the various operations.

Feeders This is the preliminary process to deliver the centers in a uniform manner to the enrober (or prebottommer).

The bulk centers are transferred by vibration and oscillation into channels, which space out the lines across the width of the belt. The lines are then transferred from the feeder belt to the wire belt (prebottommer or enrober), which is moving faster, thereby spacing out the centers longitudinally. This prevents them from sticking together at the enrobing stage.

At the transfer stage, there should be a gap with a deflector system to remove center tailings.

Prebottommers and Cold Tables As previously mentioned, prebottommers are necessary when enrobing large articles. The prebottommers should be separate mechanical units, and generally it is not satisfactory to supply them with tempered chocolate from the enrober except during the startup period.

The tempering system should be thermostatically controlled, and because the unit is more exposed than the enrober, it is usual to run the chocolate at maximum temperature but obviously avoiding loss of seed.

After coating of the bottoms, the pieces pass over a de-tailing rod to

a cold plate, which partially sets the chocolate. Thus, it will not melt on the enrober net when passing through the enrober.

Cold plates should be thermostatically controlled to avoid moisture condensation and the belt conveying the bottom-coated pieces should always be maintained in close contact with the plate. Sometimes, slight doming of the upper surface is used to achieve this. About 2 min of bottom cooling usually is enough to allow sufficient setting of the chocolate.

If condensation occurs on the cold plate due to high humidities in the enrober room, a cover can be provided to form a type of tunnel.

Coating Section

This part of the enrober consists of the following:

1. Reservoir tank. This provides tempered chocolate for the curtain and has a slowly moving agitator.
2. Pump and mixer. These lift chocolate to the flow pan and curtain of chocolate. Heated jackets are necessary and the reservoir tank must never reach a chocolate level where the pump discharges air as well as chocolate. Air bubbles in the chocolate curtain are a great nuisance. The flow pan is adjustable and the curtain discharge should be as close as possible to the tops of the units being covered.
4. Blower. This controls the thickness of the chocolate coating and can be adjusted for angle and height. Air temperatures must be watched, as overheating will cause some of the chocolate to be detempered; 82 to 85°F (28 to 29.5°C) may be considered optimum but air speed is also a factor.
4. Vibrator. After the curtain, the transport net is subject to vibration by either mechanical or electrical means. It should be possible for the amplitude and the speed of vibration to be controlled separately, but in some enrobers this is not the case. Ripples on the chocolate surface are controlled by vibration and blowing, but if the chocolate becomes overseeded, these operations may not be effective.
5. Wire belt extension. This serves as a decorating table and may be warned to ensure that excess chocolate is removed and returned to the reservoir tank.
6. De-tailing device. This has already been mentioned but correct adjustment is important. It should not be too high or chocolate will be whipped off the bottoms with the tails. It should be just touching the wire belt and not the tunnel belt.

Chocolate Cooling

A complete understanding of the principles of chocolate cooling is essential if chocolate products with a good appearance and shelf life are to be obtained.

Regrettably, the construction of coolers is often at fault, and those properly constructed are frequently used incorrectly. Little attention is given to the relative humidity of the air passing through the cooler, and in older installations, icing and deicing of the cooling units are often responsible for the introduction of damp air.

Enrober Coolers

Tunnel Coolers The following description mainly concerns enrober coolers but the conditions also apply to other chocolate equipment. The requirements for good chocolate tempering have already been described. It is necessary to ensure that chocolate in the enrober is well seeded with stable forms of cocoa butter crystals, but it must be realized that the chocolate on the enrobed centers still contains a high proportion of liquid cocoa butter that must be solidified in the stable crystal form during the cooling process.

This liquid chocolate *must not* meet very cold air, which will make the remaining cocoa butter unstable. The air in the first stage of the cooler should be at a temperature of 15 to 17°C (59 to 62°F), and under these conditions the chocolate covering will cool from about 30°C (87°F) to 20°C (68 to 70°F) and the formation of stable crystals will be ensured. In the next stage of the cooler, colder air may be used, and for enrober coolers, this is preferably not lower than 10 to 13°C (50 to 55°F), but it is undesirable for the chocolates themselves to reach this temperature. A third stage of the cooler is useful in which the chocolates again meet warmer air so that they emerge from the cooler at about 15°C (60°F). It is not generally understood by the designers of coolers that the important factor in a cooler is the *temperature gradient of the chocolate and not only the air temperatures*. With similar air conditions, chocolate pieces of different sizes can have greatly different rates of cooling and very small chocolates can soon reach the lowest temperature of the air in the cooler (in the example above, 10°C). This can produce unstable crystals, and also, in some chocolates, promote cracking of the covering due to rapid contraction.

Deposition of moisture may also occur if there is no warming section of the cooler. If air conditioning is not provided in the packing room, it is very likely that chocolates coming from a cooler at 12.5 to

14.5°C (55 to 58°F) will, on occasion in warm weather, be below the dew point.

Another disadvantage of a low-temperature section is that if the conveyor belt stops with the cooler loaded, the chocolates will soon reach the lowest air temperatures and cause the troubles mentioned above. A safeguard is to provide a means for directing the cooling air out of the tunnel when the belt stops.

Design of Coolers Many types of cooling systems have appeared over the years. Some have been designed at minimum cost, and with these many problems arise in trying to maintain the air conditions outlined above.

When a cooler, particularly a tunnel cooler, is used for a variety of chocolate articles—such as small enrobed pieces, large candy bars, or molded blocks—adjustments have to be made to air temperatures and velocities according to the load in the cooler.

Multizone Coolers Air control becomes very difficult with large enrober coolers where a single-section tunnel is used. A development that has resulted in a great improvement in temperature control is the multizone cooler. This system uses a series of separate cooling sections, each with its own air flow and cooling unit. The tunnel consists of any number of these sections in line, depending on the load and type of product to be cooled.

There are various designs of the sections of these coolers. In some, air travels horizontally at right angles to the direction of the belt movement. In others, air is directed vertically onto the top of the chocolates. (An example is shown in Fig. 7.21.) Adequate cooling of the bottoms of the covered articles is necessary or the pieces will not readily detach from the belt at the end of the tunnel.

With candy bars, uneven cooling will cause distortion as a result of the chocolate on the top of the bar setting and contracting while the bottom chocolate is still soft. Modern coolers have extra cooling applied to the bottoms by means of a separate water or air-cooled bed beneath the conveyor belt.

Radiant Cooling Radiant cooling has been the subject of much argument in the chocolate industry. The system makes use of the fact that black surfaces are capable of absorbing heat rays, and tunnel coolers were constructed in which the ceiling of the tunnel was provided with a series of matte black platens through which coolant was circulated. Radiant heat from the chocolate, theoretically, would

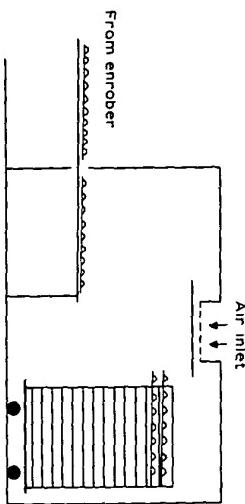


Fig. 7.16. Simple Room Cooler
Chocolate units are transferred from enrober to plaques, which are placed in racks on a trolley. The room is cooled with moving air to a temperature of 15 to 16°C (59 to 61°F), and the relative humidity is less than 60 percent. After a cooling time of 20 to 40 min, the trolley is removed from the room for packing.

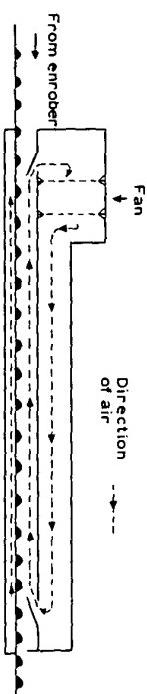


Fig. 7.17. Simple Tunnel Cooler
Cool, dry air is supplied from front-type refrigeration with a proportion going both above and below the conveyor belt. The tunnel is 8 to 12 m (26 to 39 ft) long for small units—extra length is needed for larger tablets or candy bars. Air temperatures are critical and the velocity is variable. Care is needed to prevent condensation on the chocolates at the exit.

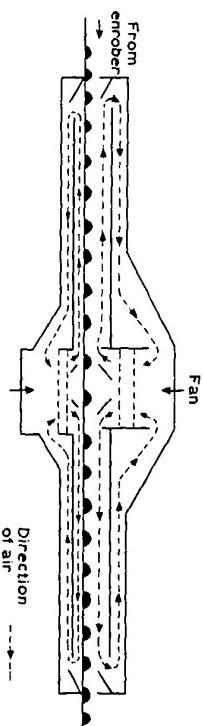


Fig. 7.18. Tunnel Cooler with Central Air Outlet
There is a separate air cooling system to the bottom of the conveyor belt. Divided air stream gives better control of the temperature at the entry and exit of the cooler. The air velocity is variable. The tunnel length is 8 to 12 m (26 to 39 ft for small units—extra length is needed for larger tablets or candy bars).

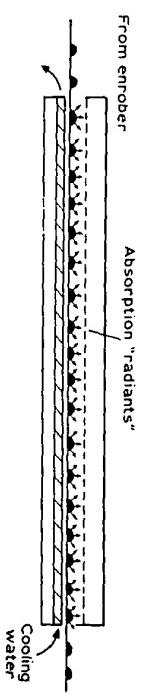


Fig. 7.19. Radiant Cooling Module
Length is 4 m (13 ft).

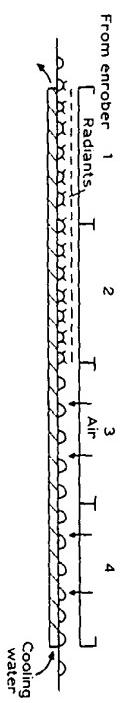


Fig. 7.20. Modules Placed in Series to Give Multizone Cooling
The first zones are radiant cooling, and the final zones are air convection cooling.

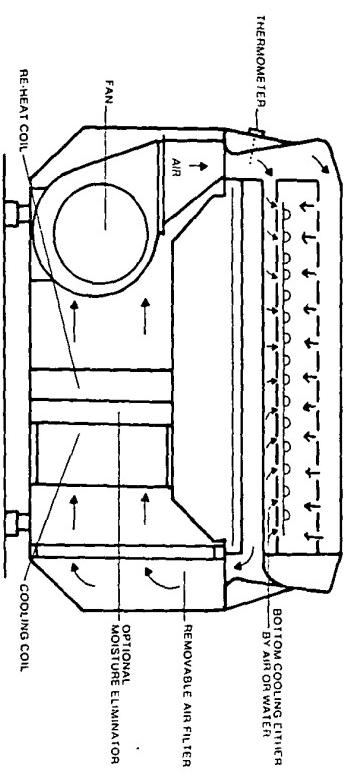


Fig. 7.21. Cross Section of Module of Multizone Cooler

Baker-Perkins, Peterborough, England

Automatic Enrober Systems

Modern enrobers are now available in which the chocolate is automatically maintained in a constant degree of temper irrespective of the quantity of chocolate passing through the system.

The Sollich Temperstatic TSN is an example and operates with enrober net widths ranging between 25 and 50 in. The throughputs are 770 lb/hr for the "62" and 1540 lb/hr for the "130."

The built-in tempering system is described below and diagrams of the chocolate circulation and enrober are shown in Figs. 7.22 and 7.23.

Tempering Chocolate from the main storage tank is fed to the heating tank and cylinder, where it is ensured that it reaches 40°C (104°F) and is completely free from cocoa butter seed. It then flows to the tempering cylinder cooling stage 1, where it is cooled to 28°C (83°F) (milk chocolate) or 29°C (85°F) (plain chocolate). Precise sweeping of the cooling surface together with intense mixing ensure full development of cocoa butter seed. The chocolate then passes to cooling stage 2, where cooling takes place at about 1°C (2°F) above stage 1.

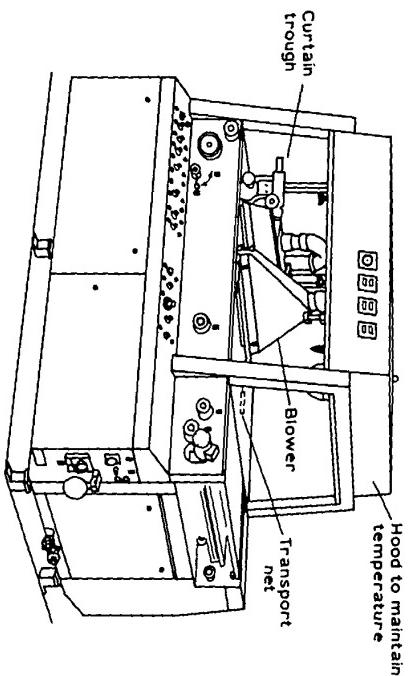


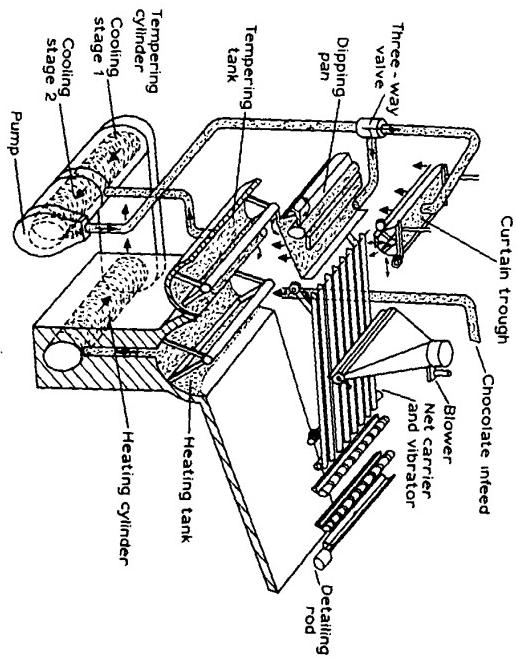
Fig. 7.22. Temperstatic® Enrober
Sollich GmbH, Bad Salzuflen, W. Germany

Fig. 7.23. Diagram of Chocolate Circulation
Sollich GmbH, Bad Salzuflen, W. Germany

At the end of cooling stage 2 is a pump that feeds chocolate to the curtain trough or dipping pan. The throughput of this pump is purposely well above that traversing cooling stage 1, and the difference is made up by a feed from the tempering tank to between cooling stages 1 and 2.

The tempering tank acts as a reservoir and is kept at a temperature just above the chocolate temperature at the end of cooling stage 1. The retention time in this tank is permanently preset and is not adjustable by the operator. It is here that any unstable cocoa butter crystals are remelted.

Since there is a continuous flow of chocolate through the tempering cylinder/tempering tank circuit, there is always a surplus of chocolate in the tempering tank. This either overflows into the heating tank or is incorporated into the chocolate from the enrober. The ratio between these flows does not affect the retention time in the tempering tank.



Temperature control is by means of a special water-circulation system.

Chocolate Enrobing Problems

In the foregoing descriptions, some of the problems may be anticipated but the following remarks are additional.

Tempering Chocolate must be properly tempered. Undertempered chocolate causes delayed setting in the cooler and adhesion to the conveyor belt, and ultimately bad chocolate color and fat bloom.

Centers Many kinds of confectionery centers are chocolate covered and these are fed by hand or mechanically onto a conveyor band and then to the enrober net, which carries them through the chocolate curtain.

One common fault arises from cold centers. If the centers have been made independently, they may be stored for a period in a cool room, particularly caramels, to retain their shape. These must be warmed before covering or the covered pieces will have a dull grayish appearance due to premature cooling of the chocolate. It is customary to bring trays of centers into the enrober room to warm up before enrobing, but here another trouble may arise, because if the centers are below the dew point of the room, condensation of moisture on the centers will occur. In its worst state, this can cause an increase in viscosity in the surplus chocolate that drains from the enrober curtain, and may promote bloom formation.

The enrober room and the centers should be at a temperature in the region of 24 to 27°C (75 to 80°F), as centers that are too warm will delay cooling and cause the chocolate to run off, giving flanges on the bottoms and bad control of unit weights.

When centers are made mechanically (e.g., by extrusion), these are fed directly from the extruder to the enrober. To warm these, a radiant heater over the conveyor is used. Centers that have been cast in starch must be very thoroughly brushed or air-blown free of dust. If this is not done, the chocolate will not coat evenly and many pinholes will form. The vicinity of the enrober must be free from drafts, which, in addition to causing bad chocolate colors, may cause setting of chocolate on the enrober net.

Fatty centers such as fudge, marzipan, and nut pastes will cause fat bloom to develop on dark chocolate coatings upon storage. The



Fig. 7.24. Distortion

addition of 2 to 4 percent of anhydrous butter fat to the chocolate coating will prevent this.

Contraction on Cooling This is a factor often completely misunderstood but may have serious consequences.

In Chapter 3 cocoa butter, contraction properties on cooling were explained in detail, and it will be noted that the degree of contraction and rate of contraction are related to cooling. If chocolate-covered centers are cooled too rapidly or unevenly, two problems are likely to occur:

1. Distortion. Figure 7.24 shows the effect of rapid cooling of the top of a chocolate-covered bar while the bottom is still soft.

2. Oozing, splitting. Figures 7.25 and 7.26 show the effects of contraction pressure causing the center to be forced through pinholes or weak patches in the covering. In some cases, the covering cracks and may separate from the center.

Distortion and oozing are worse with soft centers such as fondant or fudge. Splitting or cracking is more likely on light, aerated centers, for example, wafers or aerated hard candies.

Distortion is emphasized if the top chocolate covering is thick and the bottom thin. Oozing is frequently incorrectly diagnosed as fermentation.

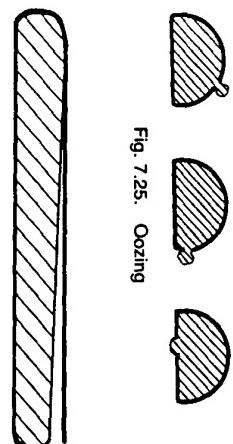


Fig. 7.25. Oozing



Fig. 7.26. Splitting

Relative Humidity of Air in Coolers and Packing Rooms It is surprising how often insufficient attention is paid to the problem of air humidity when designing coolers.

The most obvious cause of trouble is the condensation of moisture on chocolates when they arrive in the packing room from the enrober cooler. At one time, many factories worked without air-conditioned packing rooms and these same factories usually had badly designed low-temperature coolers from which the chocolates often emerged at temperatures below 13°C (55°F). During summer periods, dew points frequently rose above these temperatures and production had to stop.

In recent years, air conditioning of packing rooms has increased steadily as it was uneconomic to stop production.

A less obvious cause of trouble is high-humidity air in the cooler itself. In some designs of chocolate coolers using air at, say, 13°C (55°F), there is no accurate control of the relative humidity of the air entering the cooler. Air from outside the factory is drawn into the refrigeration system, and for economy purposes, it is merely cooled to the minimum temperature required in the cooler. The relative humidity of this air depends entirely on the dew point of the supply air and the result is that the air in the cooler can rise to 80 to 90 percent relative humidity. Since chocolate will pick up moisture from the air at 85 percent and higher (dark chocolate) or 75 percent and higher (milk chocolate), chocolate in these coolers becomes damp and will ultimately develop sugar bloom.

Another cause of trouble is high humidity during defrosting of cooling coils, or temporary failure of the cooling system. This can be very serious as air at close to 100 percent relative humidity may be introduced into the coolers and, apart from damage to the chocolates, molds can develop on chocolate residues in the cooler and on cooler surfaces. In this way, mold spores will be distributed over manufactured goods and musty odors will arise in the coolers. In any cooling system, to avoid these troubles, air intake should be partly dehydrated by reducing its temperature to well below that of the air used for circulation in the cooler. For cooling air to be used at 13°C (55°F) to 14.5°C (58°F), the intake of air should be drawn through cooling coils that reduce it to 7°C (45°F), and this air when warmed to 55 to 58°F will have a relative humidity of about 63 to 70 percent [dew point 7°C (45°F)]. At this relative humidity, no chocolate or cooler damage will occur. There are two methods of raising the air from 7°C (45°F): (1) by passing through heating coils, or (2) by mixing with the original air supply. The former method is the most positive and is recommended for enrober coolers.

As with many processes in the confectionery industry, there have been great improvements in cooling systems. The older brine circulation has been replaced by compact freon refrigeration units that can be used locally where cooling is required.

Chocolate Panning

Panning is a unique process of coating a center with successive layers of chocolate or sugar in a rotating pan known as a Volvo or comfort pan. Sugar panning is dealt with elsewhere in the book. The following description concerns only chocolate panning.

Chocolate is frequently applied to nuts. Almonds, hazels, and peanuts are usually roasted, but brazils are not.

Other centers may be raisins, malted milk balls, preserved ginger or cherries, some pastes, or nougat. The center must have some solidity or it will break up in the pan.

Usually the process consists of three separate operations:

1. Pregrazing of the center.
2. Engrossing, which means the building up of the layer of chocolate (or sugar with sugar panning)
3. Final glazing to give a glossy appearance and provide some protection from the effects of dampness and abrasion.

The pans (Fig. 7.27) are made of copper or stainless steel and particular pans are generally retained for the specific purposes of sugar coating, chocolate coating, or glazing. They may be tilted and operated at different speeds.

The pans are provided with ducts that blow air onto the units while they are rotating. It is essential for the temperature and humidity of this air to be controlled to fairly fine limits. Cool dry air is required to set the chocolate when it is being applied, but warmer dry air is required when the syrup glazes are used. Originally, the syrups and chocolate were applied by hand, but in present-day large installations, spray guns are used. These are fitted to each pan and are adjustable to direct the spray where required onto the rotating product. They are supplied by pipeline from bulk tanks, and one person can supervise a battery of pans by this method.

An example of the process stages for nut panning is as follows:

Pregrazing This is used to seal the nut surface and with a thin coating of chocolate prevents transfer of nut oil to the chocolate and

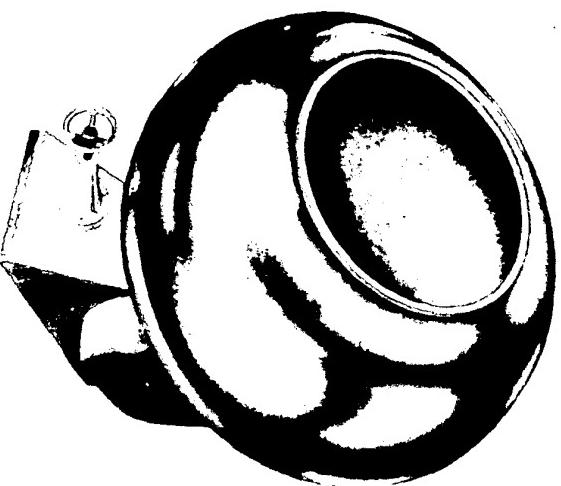


Fig. 7.27. Volvo Pan

Norman Barffell Ltd., London

subsequent development of fat bloom or softening of the chocolate. It is possible to dispense with this process with thick chocolate coatings.

To glaze the nuts, they are rotated in the pan and a syrup of 50 percent concentration is poured on in small quantities. Rotation of the pan causes this to be distributed evenly over the surface of the nuts and the air blowing onto the syrup layer will cause it to dry out as a glaze. Successive applications of syrup will increase the thickness of the glaze, but it is necessary to dry out each layer before the next application.

Various recipes have been proposed for this glazing, but for the best results, the syrup should be viscous and not crystallize from the dried glaze. To increase viscosity, gum arabic is added or a suitable substitute gum, and to prevent crystallization, glucose syrup. The actual quantities of each should be found by experiment to suit the confectionery center.

Chocolate Coating Dark or milk chocolate may be used and should be fluid enough to distribute readily over the surface of the centers being coated. With hand panning, it is better to use tempered chocolate to encourage quick setting and to prevent streaky layers and discoloration of the finished chocolates. With spray panning, good results are obtained with untempered chocolate provided the temperature has been reduced to 34 to 35°C (93 to 95°F).

The mechanical process of spraying induces a seed in the chocolate that helps the setting of the chocolate. Since finishing glazes are usually applied to panned goods, slight discoloration of the chocolate is acceptable.

The chocolate layer is built up by even application and setting is achieved by using duct air cooling at about 13°C (55°F) with humidity controlled at 60 percent or below. Care is required in this panning process to prevent agglomeration of units, and this rests largely with the operator's skill in the application of chocolate.

Finishing Glaze There are various methods of obtaining the final glaze and for the best results two distinct layers are applied—first, a syrup glaze, and second, a wax or edible shellac glaze.

The chocolate-coated centers are preferably allowed to set completely in shallow trays before glazing. This ensures a rigid unit; if they are glazed straight from the chocolate coating pan, they may distort.

The syrup glaze is similar to that used for pregazing or an edible dextrin may be used. "Crystal gums" may be used instead of gum arabic, and recipe quantities of ingredients and strength of syrup may be adjusted to suit the line being glazed—the object of the glaze being to create a polish that does not crack, flake off, or crystallize, and to serve as a base for the final glaze.

The syrup glaze is applied by pouring into the rotating mass and will quickly distribute over the surface of all the chocolate-covered pieces in the pan. Spraying is unnecessary and the entire recipe

quantity of syrup may be added in two or three successive applications with drying in between.

Air from a duct is again used for drying at a temperature of about 18°C (65°F) for milk chocolate, and 21°C (70°F) for dark chocolate, with a 50 percent relative humidity. The drying is continued until all signs of stickiness have disappeared.

After this glazing, the chocolates are best left in shallow trays at about 18°C (65°F) and 50 to 60 percent relative humidity for at least 12 hr—this stabilizes the glaze and creates a film with an equal moisture content throughout. After this period of drying, a wax or varnish glaze is applied. If this glazing is to be done in a rotating pan, a wax is usually employed and the pan itself is coated internally with a wax layer—the wax may be beeswax or carnauba wax, the latter giving a harder glaze. Compositions containing acetylated glycerides have also been proposed for these glazes. Whichever wax is used, a relatively dull polish is obtained, but for a brilliant surface, it is necessary to use a varnish prepared from edible shellac.

It is preferable to use shellac containing the natural wax as this gives a more flexible film and seems to spread more evenly. The resin is dissolved in ethyl or isopropyl alcohol and a thick opaque solution results because of the presence of wax, but the glaze obtained appears quite clear. The strength of solution depends on the confectionery being glazed but is usually 25 to 30 percent. Proprietary shellac glazes are obtainable and these are generally applied in a rotating pan. The method used needs some skill and the pan containing the pieces to be glazed is rotated and the varnish solution applied in a quantity just sufficient to distribute it evenly over the surface of each piece. As soon as this has occurred, the pan is stopped and the solvents allowed to evaporate. *The pan must not be rotated while this is happening*, or the glaze will be torn off. The solvent evaporation can be accelerated by blowing air into the pan. These solvents present an explosion hazard, and in some countries this operation must be carried out in a separate room by remote control. As soon as the glaze is dry, the pan is rotated two or three times to free the pieces and the contents emptied onto trays for final drying and hardening.

Zinsser U.S.A. has introduced a range of confectionery shellac glazes, including one that contains small amounts of beeswax and acetylated monoglyceride. This addition is claimed to reduce "tack" during rotation in the pan.

Kaul GmbH of Germany produces a range of water and alcohol-

soluble confectionery glazes under the name "Capol." These are suitable for both chocolate and sugar panning.

Shellac coating, in addition to giving a brilliant finish, provides very good protection against dampness, and because of this, glazed panned chocolate lines are particularly popular in tropical export markets.

In addition to chocolate panned goods, sugar glazing on top of chocolate is now very popular. Sugar glazing, in effect, is similar to the syrup glaze applied to chocolate units, but it is built into much thicker layers to form a hard shell. This process is described in Chapter 6.

Zein Glazes

Considerable interest has been shown in the confectionery industry in the use of zein as a protective glaze. Zein is a corn protein and there are no official restrictions or limits on its use in foodstuffs.

It is soluble in ethyl alcohol or isopropyl alcohol in proportions of 5 to 20 percent of the total weight of the solution. Plasticizers such as glycerol and propylene glycol are also used in zein solutions.

It is claimed that zein glazes may be applied in a rotating pan. They have also found considerable application in the manufacture of compressed tablets.

Descriptive brochures are available from Freeman Industries Inc., Tuckahoe, N.Y., and Benzian A.G., Lucerne, Switzerland.

REFERENCES

Manufacturers, Research Establishments

- Aasted International Bymarken, Denmark—tempering, molding
- Baker Perkins, Peterborough, England
- Norman Barillet Ltd., London, England—comfit plants
- Bandler GmbH, Bergneustadt, W. Germany—shell plants
- Coleman GmbH, Lubeck, W. Germany—hollow figure machines
- Freeman Industries Inc., Tuckahoe, N.Y.—zein glazes
- Kaul GmbH, Elmshorn, Germany—general glazes
- Lloveras S. A., Tarrasa, Spain—vermicelli
- Richardson Researches, Hayward, California
- Sollisch GmbH, Bad Saarow, W. Germany—enrobbers, coolers, Tempermeter
- Westal Company (Baker Perkins), Redditch, England—shell equipment

Zinsser and Co., Somerset, N.J.—shellac glazes
Wilton Book Division, Woodridge, Ill. (*The Complete Wilton Book of Candy*)—Hand
covering, etc.

Equipment

Many companies manufacture molding machines, enrobers, coolers, confit pans, and
the like.
Readers are advised to consult the *Directory of Equipment and Supplies*, Manf. Conf.
1986 (July) and later editions.
Many companies also advertise in the trade journals listed in the Appendix.

Confectionery: Ingredients and Processes

Confectionery Fats

Vegetable fats generally are used in great quantities in the production of all kinds of confectionery, such as caramels, fudge, nougat, truffles, and pastes for wafer and cooky fillings. The only animal fat normally used in these products is butter, with the other animal fats employed in the general baking and other food industries.

Many trees and plants supply natural oils and fats but these oils are not usually suitable for use without further physical and chemical treatment. The oil expressed from the fruit or seeds is refined, and then subjected to hardening either by glyceride separation or by hydrogenation followed by deodorization. The degree of hardening is determined by the way the fat is to be used subsequently.

The description "oil" or "fat" is often applied indiscriminately. The explanation often given is that an oil is a liquid fat and a fat a solid oil with regard to normal temperatures. When seeds or nuts are expressed, an oil is mostly produced, which is then treated further. Several hundred varieties of oil-bearing plants are known but only a few of these are of commercial importance.

Vegetable fats are usually described as domestic and nondomestic, the former obtained from crops growing in moderate climates and the latter of tropical origin.

<i>Domestic oils</i>	<i>Main producing countries (1984)</i>
Soybean oil	United States, Brazil, China (P.R.)
Cottonseed oil	United States, U.S.S.R., China (P.R.)
Peanut oil	India, China (P.R.)
Sunflower seed oil	U.S.S.R., United States
Rapeseed oil	Canada, China (P.R.), India
Olive oil	Mediterranean countries
<i>Tropical oils</i>	<i>Main producing countries (1984)</i>
Palm oil	Malaysia, Indonesia, Nigeria
Coconut oil	Philippines, Indonesia
Palm kernel oil	Malaysia, Nigeria
Cocoa butter	Brazil, Ivory Coast, West Africa, Malaysia

Additionally, there are the wild crops often called the exotic oils, and among these are illipe and shea butter. World production varies greatly but they have acquired importance in relation to the production of cocoa butter equivalent fats.

CHEMISTRY OF FATS

Chemically the fats and fatty substances are more correctly termed lipids. These consist of (1) the true fats or oils called triglycerides, (2) phospholipids, and (3) sterols.

Glycerides, Fatty Acids

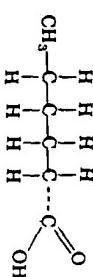
Glycerides are combinations of the trihydric alcohol glycerol with various fatty acids. Glycerol is represented chemically as



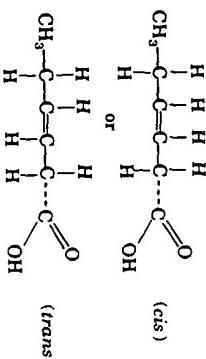
Fatty acids are mostly chain compounds. They include palmitic acid and stearic acid, which are the most abundant in natural fats.



Lauric acid is abundant in coconut and palm kernel oils. A saturated fatty acid may be represented by the following:



An unsaturated acid becomes



R_1 , R_2 , R_3 represent fatty acids and it can be seen that with different acids and positional interchange, many variations of glyceride are possible.

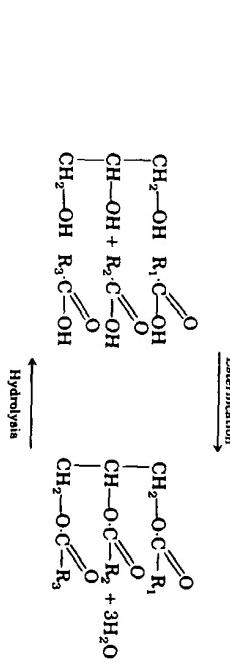
In plant life, glycerides are built up by the complicated reactions of photosynthesis. Thus, fats are formed in the seeds and fruit as a means of providing food for the new plant in its early stages of development.

Here, hydrolysis occurs usually by enzyme action (lipase). In the production of fats from natural sources, premature action by enzymes must be avoided to prevent the fat from containing free fatty acids. The presence of free fatty acid can have a profound effect on the flavor of a fat as is exemplified by lauric (C_{12}) fat.

Phospholipids, Sterols

These substances occur in fats, usually less than 0.5 percent. The best known phospholipid is lecithin.

Sterols are fat-soluble ring compounds and cholesterol is well known, which is mostly present in animal fats. The fat-soluble vitamins are closely related to the sterols.



These have links termed 'double bonds' and different fatty acids may have one, two, three, or occasionally four double bonds. The presence of these bonds will greatly increase chemical reactivity and susceptibility to rancidity of the fat formed from them. Also, the melting point is generally lower. The chemistry of hydrogenation is related to the presence of double bonds (see later).

In the formation of a glyceride, the glycerol molecule becomes esterified with the fatty acid, losing three molecules of water in the process. Alternatively, a glyceride may be hydrolyzed into glycerol and the free fatty acid.

The following chemical formulas indicate the reversible reaction:

PRODUCTION AND PROCESSING OF FATS

Fats are extracted from the natural seeds or fruits by combined processes of expeller pressing and solvent extraction. The raw fat so obtained is unsuitable for use in food and must be refined.

Refining is carried out in three stages:

1. Neutralization. The fat is washed with alkali solution, which removes residual fatty acids in the form of a soap.
2. Bleaching. The hot liquid fat is mixed with an absorbent substance (fuller's earth) and decolorizing carbon, followed by filtration. This removes odorous substances, color, and slime.
3. Deodorizing. This process is described under "Cocoa Butter" and removes the last traces of undesirable volatiles. The refined fat so produced is practically unchanged physically and for most confectionery uses must be hardened.

Hardening Fats

Two basic processes are used—one physical and the other chemical.

Physical Glyceride Selection Removal of some of the lower melting components in a fat usually results in a simpler mixture of glycerides and widens the scope of available fats.

The technique originally applied to coconut and palm kernel oils was to allow the liquid fat partially to solidify under controlled conditions so that it contained a mixture of solid fat crystals and liquid fat. It was then submitted to hydraulic pressing, thus separating the fat into stearines (higher melting points) and oleines (liquid). This method of crystallizing and pressing is not sufficiently selective for many requirements and new techniques of separation are now used. These are based on fractional crystallization from suitable solvents such as acetone, which enables a much greater control to be exercised over separation of required glycerides, by this technique it is possible to isolate fractions in which single glycerides predominate. Stearines from coconut and palm kernel oils are hard brittle fats with melting points similar to that of cocoa butter, and find a ready use as fats for confectionery coatings. Their properties arise from a small number of similar glycerides present, in which myristodilauroin predominates. These stearines, although used considerably as cocoa butter substitutes, unfortunately give rise to eutectic effects when some cocoa butter is present, and the resultant mixture of fat

components of a coating may be too soft. To produce a satisfactory cocoa butter alternative fat, free from eutectic effects when mixed with cocoa butter, a more specific selection of glycerides similar in chemical constitution to those present in cocoa butter itself is required (see "Equivalent Fats").

Coconut and palm kernel stearines are also subject to saponification in circumstances where breakdown of the fat occurs,

liberating the free lauric acid (see Lipase Activity).

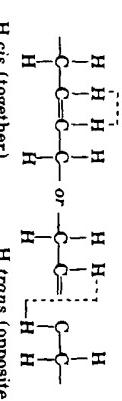
Chemical Hardening (Hydrogenation) Generally speaking, the saturated fats have higher melting points and are harder than unsaturated fats. The glycerides of the various fatty acids may be saturated or unsaturated.

The unsaturated acids, which have lower melting points, may be converted to saturated acids by combining with hydrogen. Therefore, the degree of hardening that may be effected is governed by the amount and type of unsaturated acids present in an oil.

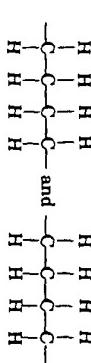
For most edible-oil requirements, partially hardened oils are used and the relationships among texture, plasticity, and melting point are of great importance. In order to understand how these properties are manipulated, some knowledge of the chemistry of the reaction is necessary.

The Chemistry of Hydrogenation Fatty acids have long chains of carbon atoms (each having four bonds) to which are attached hydrogen atoms.

An unsaturated acid chain has the following structure:



These double bonds between carbon atoms combine with hydrogen to form saturated acids:



which are identical, whether from "cis" or "trans" unsaturated acids. A diunsaturated fatty acid contains two such double bonds and a triunsaturated acid three.

When hydrogenation commences, the triunsaturated acids are converted to diunsaturated acids, and then monounsaturated acids, and finally to saturated acids. At the same time, the existing diunsaturated acids are converted to monounsaturated and then saturated, whereas the existing monounsaturated are converted to saturated acids.

If all these processes occur together, the process is nonselective, whereas if the triunsaturated acids are hydrogenated preferentially, followed by the diunsaturated, etc., the process is selective.

Depending upon the type of reaction taking place in the intermediate states, a semihardened oil will have different characteristics, but a completely hardened oil will have all acids saturated and will finish up with the "same characteristics.

In addition, the "cis" and "trans" acids may change formation from one to the other, and the double bonds in unsaturated acids may change their relative position in the chain, forming "iso" unsaturated acids.

These changes also affect the physical characteristics of any semi-hardened oil, but to a lesser degree than selective and non-selective hardening.

Vegetable oils are hydrogenated by bringing them into intimate contact with hydrogen gas at suitable temperature and pressure.

The oil is heated to 120°–180°C (248° to 360°F) in a closed vessel containing hydrogen under pressure, and contact is brought about by vigorously stirring the oil or by passing the hydrogen through the oil in the form of fine bubbles. The reaction takes place in the presence of a catalyst, usually nickel, which is deposited on *kieselguhr* in a very finely divided state.

The method of preparation and deposition of the catalyst is very important because it influences both the activity of the catalyst and the selectivity of the reactions.

The science of hardening an oil to obtain the desired relationship between melting point and texture for any given degree of hardening depends upon precise knowledge of the temperature and time of hydrogenation and the activity of the catalyst.

COMMERCIAL EDIBLE OILS

Table 9.1 gives a summary of the structure of the common edible oils. A brief description of those important in the confectionery industry follows.

Coconut oil

The coconut is a well-known product of the palm of the same name, which grows on the islands and in the coastal areas of tropical countries. The nut has a hard outer husk and inner kernel and it is this kernel that is dried to give the article of commerce known as copra from which the crude coconut oil is expressed.

Characteristics The average oil content of copra is 66 percent, and dependent upon its qualities, yields a white to brownish-yellow fat. This fat is somewhat crystalline in appearance and possesses a marked degree of brittleness at low temperatures, but as its melting point is 25°C (77°F), it becomes soft and almost liquid at normal summer temperatures. Before refining the fat has a flavor that can vary from that of fresh coconut to a disagreeably harsh taste, but after refining the oil is odorless and tasteless, of good white appearance, and stable.

Chemical Nature Coconut oil is distinguished chemically from many other fats by the presence of large quantities of glycerides of lower saturated fatty acids, for example, lauric and myristic acids, as well as small quantities of the short-chain volatile acids—caproic, caprylic, and capric. Unsaturated fatty acids are present in small amounts only, thus giving excellent stability against the development of oxidative rancidity.

The rather unusual fatty acid composition of coconut oil accounts for its high saponification value, high Reichert and Polenske values, and low iodine value.

These fatty acids are combined in coconut oil to give different triglycerides with the lauric and myristic acid triglycerides predominating. These particular triglycerides are present in large quantity and account for the fact that coconut oil does not soften gradually with increasing temperatures, but passes rapidly from a hard solid to a liquid state within a range of a few degrees.

The small content of glycerides of unsaturated fatty acids is sufficient for hydrogenation to be applied and the sharp melting coconut oil may be hardened to a product of longer plastic range and higher melting point.

Palm Oil, Palm Kernel Oil

The oil palm is a native of tropical West Africa but is now also cultivated in Malaya and Indonesia. The fruit of the palm is unusual

TABLE 9.1. TYPICAL COMPOSITIONS AND CHEMICAL CONSTANTS OF COMMON EDIBLE FATS AND OILS (Fatty acid compositions were determined by gas-liquid chromatography and are expressed as mean average weight percent compositions on a fatty acid basis. Trace acids (less than 0.1%) are excluded.)

Fatty acid	Carbon atoms*	Butterfat	Cocoa butter	Coconut oil	Corn oil	Cottonseed oil	Lard	Olive oil	Palm oil	Palm kernel oil	Peanut oil	Rapeseed oil	Rapeseed oil (low erucic)	Sesame seed oil	Soybean oil	Sunflower seed oil	Tallow (beef)	Tallow (mutton)
Butyric	4:0	3.8																
Caproic	6:0	2.3		0.5									0.3					
Caprylic	8:0	1.1		8.0									3.9					
Capric	10:0	2.0		6.4			0.1					4.0						
Undecanoic	11:0	0.1															0.1	0.2
Lauric	12:0	3.1		48.5			0.1		0.3	49.6						0.5	0.1	0.3
Tridecanoic	13:0	0.1																
Myristic	14:0	11.7	0.1	17.6		0.9	1.5		1.1	16.0	0.1	0.1			0.1	0.2	3.3	5.2
Myristoleic	14:1	0.8														0.2	0.3	
Pentadecanoic	15:0	1.6					0.2									1.3	0.8	
Pentadecenoic	15:1															0.2	0.3	
Palmitic	16:0	26.2	25.8	8.4	12.2	24.7	24.8	13.7	45.1	8.0	11.6	2.8	3.9	9.9	11.0	6.8	25.5	23.6
Palmitoleic	16:1	1.9	0.3		0.1	0.7	3.1	1.2	0.1		0.2	0.2	0.2	0.3	0.1	0.1	3.4	2.5
Margaric	17:0	0.7				0.1	0.5				0.1					1.5	2.0	
Margaroleic	17:1	0.2					0.3									0.7	0.5	
Stearic	18:0	12.5	34.5	2.5	2.2	2.3	12.3	2.5	4.7	2.4	3.1	1.9	5.2	4.0	4.7	21.6	24.5	
Oleic	18:1	28.2	35.3	6.5	27.5	17.6	45.1	71.1	38.8	13.7	46.5	23.8	64.1	41.2	23.4	18.6	38.7	33.3
Linoleic	18:2	2.9	2.9	1.5	57.0	53.3	9.9	10.0	9.4	2.0	31.4	14.6	18.7	43.2	53.2	68.2	2.2	4.0
Linolenic	18:3	0.5				0.9	0.3	0.1	0.6	0.3		7.3	9.2	0.2	7.8	0.5	0.6	1.3
Nonadecanoic	19:0															0.1	0.8	
Arachidic	20:0		1.1	0.1	0.1	0.1	0.2	0.9	0.2	0.1	1.5	0.7	0.6		0.3	0.4	0.1	
Gadoleic	20:1	0.2						1.3			1.4	12.1	1.0					
Eicosadienoic	20:2							0.1			0.1	0.6						
Arachidonic	20:4	0.1						0.4									0.4	0.4
Behenic	22:0										3.0	0.4	0.2		0.1			
Erucic	22:1											34.8						
Docosadienoic	22:2											0.3						
Lignoceric	24:0										1.0	1.0	0.2					
Iodine value																		
range	25-42	32-40	7-13	110-128	99-121	53-68	76-90	45-56	14-24	84-102	97-110	110-115	104-118	125-138	122-139	33-50	35-48	
Saponification value range	210-240	190-200	248-264	186-196	189-199	192-203	188-196	195-205	243-255	188-196	168-183	—	187-196	188-195	186-196	190-202	192-198	

* Number of double bonds shown by second figure, e.g., 18:3.
Reproduced by permission of Durkee Foods, Cleveland, Ohio.

in that it yields oil from the fruit and the kernel—the fibrous layer of pulp on the outside gives palm oil and the hard kernel supplies palm kernel oil and the yields of crude oil are approximately 56 percent and 50 percent respectively.

Palm Oil Refined palm oil is a pale yellow fat with good keeping properties. It is soft in consistency and melts completely at about 40°C (104°F).

Glyceride Composition The glycerides of palm oil consist of approximately 10 percent trisaturated glycerides, 50 percent monounsaturated glycerides, 30 percent diunsaturated glycerides, and 10 percent triunsaturated glycerides. The trisaturated glycerides consist mainly of tripalmitin, which is not a common feature of natural fats where mixed glycerides are the rule rather than the exception.

This glyceride composition, ranging as it does from triunsaturated glycerides through di- and monounsaturated glycerides to fully saturated ones, gives refined palm oil its soft texture and reasonably long plastic range and makes it satisfactory for so many purposes.

Hydrogenation Owing to its relatively high iodine value, palm oil may be hydrogenated to any desired melting point, usually to between 40 to 42°C (104 to 107.6°F) and 46–48°C (114.8 to 118.4°F). Complete hydrogenation gives a melting point of about 58°C (136°F). Hydrogenated palm oil is a useful ingredient of fat blends incorporating any desired degree of stiffness; the consistency of palm oil may be increased by incorporation of the hydrogenated oil.

Palm Kernel Oil In many respects, refined palm kernel oil bears a close resemblance to coconut oil. It is a white solid fat, somewhat less brittle than coconut oil but with the slightly higher melting point of 28 to 29°C (82.4–84.2°F). Its iodine value is higher than that of coconut oil, owing to a higher unsaturated fatty acid content. The oil is composed mainly of glycerides of lauric and myristic acids. Short-chain volatile acids are present, but in a lesser quantity than in coconut oil.

This fatty acid composition accounts for the high saponification value and for the high Reichert and Polenske values, which are, however, lower than those for coconut oil. The unsaturated fatty acid content, although higher than that of coconut oil, is still quite low, and thus does not favour the development of oxidative rancidity.

Glyceride Separation It is possible to separate suitable glycerides from palm kernel and coconut oil, and these form the basis of the

well-known palm kernel stearines, which have physical properties resembling the more expensive cocoa butter, being hard brittle fats with melting points significantly below body temperature.

The higher content of unsaturated fatty acids renders palm kernel oil a very suitable fat for hydrogenation, and a useful range of hardened palm kernel oil products may be obtained according to the degree of hydrogenation.

Peanut Oil, *Arachis* Oil

The nut from which the oil is obtained is now of great commercial importance and is grown widely in tropical and subtropical countries.

Peanuts come from a small annual plant that reaches maturity in about four months. The yellow flowers change into pods that bury themselves in the ground, and there they enlarge and ripen. They then have rough ribbed shells around the kernels, the latter containing about 45 percent of oil.

Physical and Chemical Nature of the Oil Peanut oil is used for almost every edible purpose.

The color of the unrefined oil varies from a light brown to a water white, and has a distinct nutty flavor. It is liquid at normal temperatures, but at lower temperatures deposits a crystalline stearine. As can be seen from the fatty acid composition, its degree of unsaturation makes it a very suitable fat for hydrogenation.

Fatty Acid Composition See Table 9.1. It has been suggested that differences in climatic conditions might account for the variations in the linoleic/oleic acid ratios found in nuts received from different sources. One look at Table 9.2 might suggest that the cooler temperatures give rise to a greater linoleic content but a lower oleic content, and vice versa.

TABLE 9.2. PEANUT OIL—CLIMATIC CONDITIONS AND FATTY ACID COMPOSITION

	Saturated	Oleic	Linoleic
Spain	22	53	25
Philippines	18	55	27
West Africa	18	65	17
Senegal	15	66	19

The fatty-acids composition of peanuts of different origin could well be related to the great differences in keeping properties of roasted nuts. This has been the subject of research and is discussed elsewhere.

Soya Oil

The soya bean had its origin in eastern Asia but enormous expansion of its cultivation has occurred in the United States during this century. As a result, soybean oil has become one of the world's leading sources of vegetable oil in spite of the fact that the bean contains about 20 percent. Along with this, however, it is very rich in protein (40 to 50 percent), which makes the extracted meal a valuable animal fodder.

As it is a cheap source of protein a great deal of research has been done to make it suitable for human consumption. Soya flour has a peculiar earthy flavor that must be removed if it is to be fully acceptable as a major constituent of human food.

The soya bean plant has clusters of small purple flowers that develop into two to five having seed pods. The beans are oval and range in color through yellow, green, and black. The plant grows best in warm, damp climates but adapts itself to a variety of conditions, provided the soil is rich and well drained.

Cottonseed Oil

It was long after the plant was cultivated for cotton that the seed became an important source of vegetable oil.

The mature plant produces fluffy white seeds called cotton bolls with the fiber adhering. The seeds are oval, about $\frac{3}{16} \times \frac{3}{8}$ in., and yield from 15 to 25 percent of oil.

It is a plant of tropical or subtropical regions.

Sunflower Seed Oil

The plant is very tall (5 to 8 ft), although there are dwarf varieties. The flower has a dark-brown center with yellow petals. It is native to Central America but is now cultivated in many parts of the world.

The U.S.S.R. is the main producer. Originally the seed contained 20 to 30 percent of oil but the cultivation of new strains has led to an increase to 40 percent.

Sesame Seed Oil

Sesame seed originated in China and India. Today it is also grown extensively in Africa and Mexico. It is a crop that grows in poor soil and is easily cultivated. The seed contains about 50 percent oil, which has uses similar to those of olive oil.

Rapeseed Oil

Rapeseed can be grown in colder climates and in recent years countries like Sweden, Denmark, Poland, and Canada have increased production considerably, thereby reducing consumption of imported tropical oils. The plant is of the *Brassica* (cabbage) family and fields when in flower are brilliant yellow. Rapeseed contains 35 to 40 percent oil. Rape oil from original seed contained a high proportion of erucic acid that has been shown to be dietetically undesirable. New genetic varieties of seed have been developed giving oil of low erucic acid content.

Olive Oil

The olive tree has been a source of edible oil for many centuries and olive oil, although perhaps now not so important commercially, is the highest-quality vegetable oil and greatly prized for table use. The tree grows in the countries around the Mediterranean, with Spain and Italy the main producers. The fruit contains about 15 percent of oil.

Corn Oil

This has been an important edible oil of recent years, produced as a by-product of the vast starch, glucose syrup, and dextrose industry. Corn oil is pale yellow in color, liquid at normal temperatures but deposits a small amount of stearine at lower temperatures. The oil is almost entirely in the germ, which is separated in the early stages of wet milling and starch extraction.

Corn is a major crop in the United States and as a result of intensive scientific development there is an ever-increasing supply of derived products—not only in the food industry but also such materials as adhesives and paper.

CHEMICAL AND PHYSICAL PROPERTIES OF OILS AND FATS

In the examination of oils and fats, specific chemical and physical tests are used. The significance of the figures obtained by the analyst is of importance to the technologist and the meaning of the more important tests is summarized in the following descriptions.

Saponification Value

This is the number of milligrams of potassium hydroxide (potash) required to saponify 1 g of oil or fat.

The results of this test are indicative of the nature of the combined fatty acids present, for example, values above 200 indicate the presence of fatty acids of low or fairly low molecular weight, and values below 190 indicate the presence of high-molecular-weight fatty acids. Coconut and palm kernel oils consist of glycerides of fatty acids with low molecular weights and hence have saponification values between 240 and 265. On the other hand, rapeseed oil containing large amounts of a high-molecular-weight fatty acid (erucic acid) has an average value of 175.

Acid Value

This is the number of milligrams of potassium hydroxide required to neutralize the free fatty acid of 1 g of oil or fat.

Normally, the free acidity is expressed as a percentage of the major fatty acid present, for example, coconut and palm kernel oils are expressed in terms of lauric acid, molecular weight 200; palm oil as palmitic acid, molecular weight 256; and liquid oils (peanut, cottonseed, etc.) as oleic acid, molecular weight 282. It is interesting to note that there is evidence to show that the mean molecular weight of the free acids in an oil or fat may differ somewhat from the mean molecular weight of the combined fatty acids. The free fatty acids if calculated as oleic acid (mol. wt. 282), as it often is, is *half* the acid value.

Acid values, however expressed, are of value to the refiner of crude oils as indication of the amount of free acid to be removed; applied to neutral oils, they show how well this has been carried out. To users of refined products, low acid values indicate purity, but better still, if applied to stored products at regular intervals they will indicate deterioration if regular increases occur.

Unsaponifiable Matter

This refers to material present in an oil or fat, that remains nonvolatile on drying to constant weight at 80°C (176°F), after the saponification of the oil or fat by alcoholic caustic potash and extraction by a specific solvent.

Unsaponifiable matter as defined above includes, among other things, hydrocarbons, higher alcohols, and the sterols, cholesterol and phytosterol. The method of determination has been designed to exclude free fatty acids, soaps, and mineral matter; readily volatile substances will be removed during the period of drying.

The majority of oils and fats have unsaponifiable contents below 2 percent; many have values below 1 percent. A few, however, have much higher values, up to 10 percent, and in these cases, the normal method has been modified to avoid the formation of troublesome emulsions; shea nut oil is a typical member of this group. With substances like wool fat (lanolin), which contains a high proportion of wax esters, saponification is sometimes difficult to effect in one operation. In such instances, the unsaponifiable matter is obtained in the normal way and then subjected to a further saponification with caustic alkali; reextraction of the saponified product should then yield the unsaponifiable matter free from contamination.

As stated above, the majority of oils and fats have low contents of unsaponifiable matter that consists mainly of sterols. It has been found that cholesterol is the sterol present in the unsaponifiable matter of animal oils and fats, whereas vegetable oils and fats contain phytosterol. If the acetates of these two sterols are prepared and melting points determined, it is found that cholesterol acetate has a much lower melting point than phytosterol acetate and this fact has been used to distinguish between animal and vegetable products.

Iodine Value

This is a measure of the degree of unsaturation in oils and fats and denotes the percentage by weight of halogen, calculated as iodine, absorbed under standard conditions.

Where the proportion of saturated acids is high, as in coconut oil and similar fats, iodine values are low, but with liquid oils the values are high and range from 80 to 200. Oils of the highest value, such as linseed oil, will absorb oxygen from the air and find use in surface coverings, but oils used for edible purposes have lower iodine values; these run from 80 to 130, of which peanut oil (85 to 95) and cottontail oil (105 to 115) are the most common.

Iodine values are useful in deciding purity, but their main function is in plant control of hydrogenation. As partial hydrogenation is usually carried out, determination of iodine value is very important, as the decrease in this value will indicate the degree of saturation attained.

Volatile Fatty Acids

The Reichert value is a measure of the water-soluble steam volatile fatty acids present in an oil or fat. The Polenske value is a measure of the water-insoluble steam volatile fatty acids present.

The Kirschner value is a measure of the water-soluble steam volatile fatty acids present that form water-soluble silver salts. These processes do not determine the total quantities of steam volatile fatty acids present and hence are merely empirical values, but by strict adherence to the dimensions of the apparatus used and details of procedure, they afford useful information as to the presence or absence of certain fats in a mixture.

All the values are concerned with the presence of short-chain fatty acids in a fat and are applicable to butter fat and coconut and palm kernel oils. Cow butter and other milk fats are unique in possessing glycerides containing butyric acid $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$, and as this acid is water soluble, high Reichert values are obtained. Insoluble volatile acids are practically absent from these fats and hence Polenske values are very low.

With coconut and palm kernel oils, however, the picture is somewhat different. These oils contain both soluble and insoluble acids and therefore significant Reichert and Polenske values are obtained; they do not, however, contain butyric acid.

The Kirschner value is practically specific for butyric acid and is of value in indicating whether other fats containing volatile acids (e.g., coconut, palm kernel) have been added to butter and other milk fats.

It must be emphasized that the tests are empirical and the results, unlike the saponification and iodine values, are not additive, but a fair approximation of the presence of coconut and palm kernel oils in a mixture in which butter fat is absent may be obtained by considering the sum of the Reichert and Polenske values.

Peroxide Value

The peroxide value is a measure of the peroxides contained in the oil or fat expressed as milliequivalents of peroxide oxygen per kilogram of sample.

When oils and fats are subject to oxygen absorption there is a small but steady increase in the oxygen uptake as measured by peroxide value until a point is reached when the rate of oxygen uptake is materially increased. The time to reach this point is referred to as the induction period and is considered to indicate the stability of the product under test. Determinations of induction periods are carried out under conditions of accelerated oxygen absorption (i.e., at high temperatures) and there is considerable argument as to whether they are truly indicative of shelf life. The author has shown that the test can be of great value in the assessment of the stability of certain fats and fatty foods but it is desirable to run experimental parallel shelf-life tests in the first instance on the products being investigated.

PHYSICAL TESTS

Specific Gravity and Apparent Density

The specific gravity at t [15.5°C (59.9°F)] in air of an oil is the ratio of the weight in air of a given volume of the oil at $t^\circ\text{C}$ to that of the same volume of water at 15.5°C (59.9°F). The apparent density (grams per milliliter) in air of an oil at $t^\circ\text{C}$ is the weight in air, expressed in grams, of 1 ml of the oil at $t^\circ\text{C}$.

These definitions have been in use in the fatty oil industry for many years, they are specific for the industry. In other industries, these properties may be defined in a different way. These are useful as much fatty oil is delivered in bulk form these days.

It is interesting to note that hydrogenated oils have lower specific gravities than the unhydrogenated oils from which they were produced. It is found that the reduction in specific gravity is approximately proportional to the degree of saturation applied.

Specific gravity is used in conjunction with other figures in assessing purity of an oil.

Melting or Fusion Point, Slip Point, Complete Fusion

A great deal of argument has arisen in the fat industry and between fat suppliers and users concerning the method to be employed for the determination of the melting and softening points of fats.

The capillary method used in many laboratories is given in the Appendix and defines the test as follows:

Fusion point—the temperature at which softening is first seen.

Slip point—the temperature at which the fat starts to rise in the tube.

Clear point (complete fusion)—the temperature at which the fat clarifies.

By negotiation between the chemists of suppliers and users it is usually possible to agree on the precise details of the tests so that any variability of fat deliveries can be detected. It is best to agree to use recognized standard methods such as British Standards, International Union for Pure and Applied Chemistry (IUPAC), or Wiley.

Softening Point

The Barnicoat point is a more precise and reliable test than the slip point and is advocated by the fat manufacturers. See Appendix.

Flow and Drop Point

The method was devised by Ubbelohde.

A special apparatus is required, one determination only may be carried out at a time and the time taken is rather long. The method briefly is as follows: A sample of the fat, in fine shavings, is placed in a small cup with a standard-size orifice. This cup fits round the bulb of a special thermometer arranged so as to be in contact with the sample and heat is applied. The temperature at which the sample is observed to move through the orifice is recorded as the flow point, and when the first drop of melted fat falls from the cup this is recorded as the drop point.

Dilatation Test (Solids/Fat Index)

The dilatation of fat may be defined as the isothermal expansion from solid to liquid, of a fat that due to change of state has previously been solidified under carefully prescribed conditions.

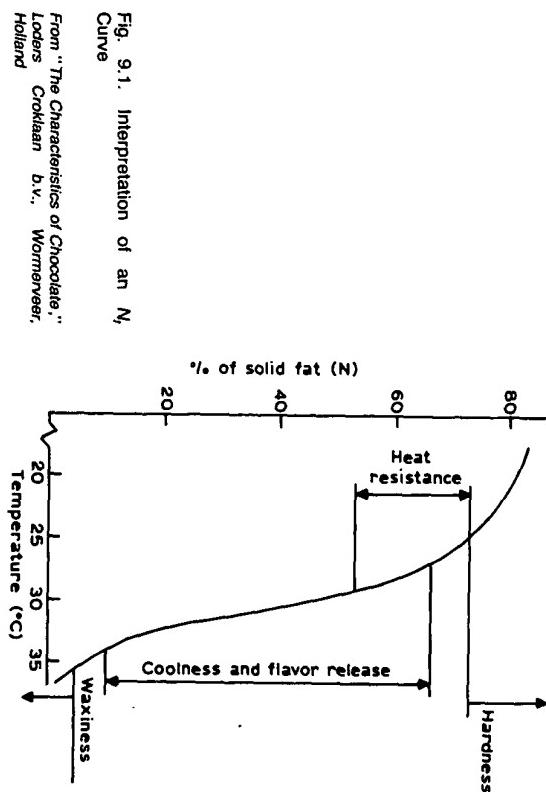
The majority of fat products consist of intimate mixtures of solid and liquid glycerides and it is possible to estimate the percentage of solid fat present at any given temperature by means of dilatometry.

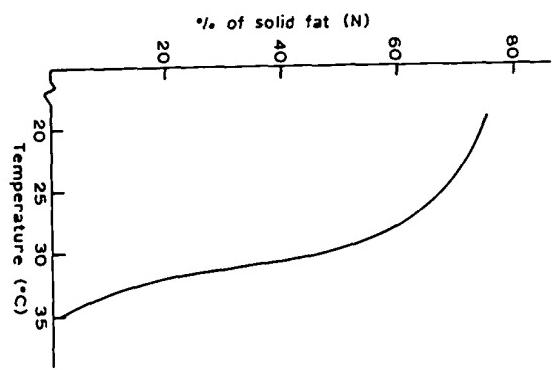
It has been observed experimentally that 100 g of completely solidified fat expand in volume approximately 10 ml (10,000 microliters) on melting. The dilatation is usually expressed in

microliters per 25 g of fat and represents the difference between the volume of solid fat and the volume of the liquid at the same temperature. A dilatation expressed in microliters expansion per 1 g is often referred to as the percentage of crystal fat present at a given temperature. It is useful to plot dilatation values against temperature readings; the shape of the resultant curve yields useful information about the product and also shows precisely the point of complete fusion. Dilatometry is more objective in application than melting point methods and can determine the ratio of solid and liquid phases at any temperature below that of complete fusion.

Dilatation results give useful information on the texture of fats at temperatures between ambient and complete melting but penetrometer values should also be determined (see "Hardness"). In companies where large quantities of fat are being produced or used, the solid fat content is measured by nuclear magnetic resonance. It gives a more accurate picture of the physical nature of a fat than dilatation.

Preparation of the sample must be standardized and is described in IUPAC method 2.141 "Determination of the Dilatation of Fats." Solids content are expressed as N_1 values and the properties of a fat may be indicated graphically (Figs 9.1 and 9.2).



Fig. 9.2. The N_1 Curve of Cocoa Butter

From "The Characteristics of Chocolate," Loders Croklaan b.v., Wormerveer, Holland

Cooling Curve—Setting Point
The cooling curve determination is of most value in assessing the supercooling quality of fats of the cocoa butter type where tempering or seeding of that fat or coating containing the fat is required, as in enrobing.

With fats that exhibit supercooling, a point is reached when the latent heat of solidification overcomes the cooling effect, and the temperature begins to rise, finally reaching a maximum point. This is called the setting point. If temperature readings throughout the test are plotted each minute, the shape of the resultant curve can yield useful information regarding the likely behavior of the fat in use. Cooling curves are discussed under "Cocoa Butter". It is essential that standard procedures be observed to obtain reproducible results.

PACKING AND STORAGE OF FATS

Fats are usually received into a factory in three ways—in solid blocks in fiberboard containers, in solid form in drums, or in liquid

important property. The hardness is not necessarily indicated by the results obtained from dilatation and melting point and a penetrometer test is a useful additional value to obtain.

The method uses the standard penetrometer as employed for the testing of bitumen (IP 49 and ASTM D5). Either the standard penetrometer needle or cone may be used, depending on the consistency of the fat. Tests are normally made at temperatures ranging between 15.6°C and 29.4°C (60°F and 85°F), and by plotting penetrometer values against temperature a very good picture of texture change with temperature is obtained.

The penetrometer is of particular value as a routine check on deliveries of fat and on samples of any standard product where, for reasons of economy or supply, it has become necessary to substitute, wholly or partly, one fat by another. The test is empirical and the procedure depends on how the fat is to be used, but it is important to prepare the blocks of fat for testing by a standard procedure of tempering (seeding) and cooling. (See Appendix.)

Refractive Index

This is a measure of the extent to which an oil or liquid fat will bend a beam of light as determined by refractometer. The refractive index is allied to the iodine value in that it also indicates the degree of unsaturation, oils of high iodine value having a high refractive index. Owing to the rapidity with which a test may be carried out, it is a useful guide during hydrogenation, but generally it is less informative than iodine value.

Fatty Acid Composition of Glycerides

The traditional method of separating and determining the component fatty acids of the various glycerides was extremely complex and time consuming.

Since the development of chromatography in its various forms (including thin-layer chromatography and HPLC), the problem of analysis has been greatly simplified. It is speedy, more accurate, and uses less material.

Hardness

When a fat or mixture of fats is used in a coating or filling, the texture of the products at different temperatures is often a very

form in tank trucks. Fat is an expensive ingredient and needs care in storage and melting. In the solid form, it will keep for three to six months in cool conditions (i.e., 15°C/60°F or less) with relative humidity of the order of 55 to 65 percent.

Fiberboard Cartons

These must be stored in dry conditions—damp packing will cause the surface fat on the blocks to deteriorate. When unpacking and transferring the fat for melting, great care must be taken to avoid packing material, particularly polythene, getting into the liquid fat.

Drums

Fat in drums presents a considerable problem when it comes to emptying and melting. To dig the fat out manually is expensive in labor and may result in foreign matter contamination from the drum interior.

Melting can be achieved by means of electrically heated jackets or steam coils, but local overheating must be avoided at all costs and temperatures up to 60°C (140°F) for short periods only are permitted. If melting is carried out slowly, as in a hot room, 52°C (125°F) should not be exceeded.

Solid fat (from cartons) is often subjected to gross mishandling during melting, particularly if large pieces are involved.

Fat so melted in a steam-jacketed pan can reach temperatures of 100°C (212°F) and over very quickly, and sometimes the fat is left at this temperature for a considerable period awaiting use in a production department.

The fat is best melted at a maximum of 60°C (140°F), but preferably 52°C (125°F) if time of melting is extended. Stainless-steel pans should be used, *never* copper. Stainless-steel metal pipe grids heated internally with low-pressure steam or hot water are best and blocks of fat can be rested on these.

Fat that is overheated may not show immediate deterioration due to a delayed chemical process known as the induction period. Such fats, which may have been included in a product, will develop rancidity and off-flavors in due course.

Fat that has been chipped for production use is often transported through the factory in trolleys. Exposure of these to bright light near windows will promote rancidity. Fat residues in the trolleys must be removed regularly.

Bulk Storage

Refined oils should not normally be stored in bulk for more than ten days or hydrogenated oils, fourteen days.

The tank site should be chosen to minimize the length of pipeline, especially from the tank to the point of use. Tanks should be housed away from dust that may carry yeasts or enzymes. Either cylindrical or rectangular tanks are suitable and, although a steel tank is adequate for most vegetable oils and fats, stainless-steel or glass-lined tanks are preferred. Tanks should be covered and have dished or similar bottoms to facilitate complete drainage, the take-off pipes being at the lowest point. The tanks should be properly lagged and heated so as to avoid local overheating. The use of hot water jackets or coils is satisfactory but where a number of storage tanks is used, it is often the practice to have them sited in a thermostatically controlled hot room, thereby avoiding the need for jacketing and lagging. Air filters to remove dust and associated microorganisms should be fitted so that air entering the tanks as fat is withdrawn does not cause contamination.

The air may be drawn over ultraviolet sterilizers and nitrogen can be drawn in in place of air.

It is desirable to maintain the temperature of the oil in the storage tanks as low as possible, commensurate with keeping the oil completely liquid in the tanks and associated pipelines. The delivery pipe should be heated and lagged. A maximum of 50°C (122°F) is desirable.

Cleaning of Tanks

An accumulation of oxidized oil, pipe scale, or other foreign materials in tanks or pipelines may impair the keeping properties of fresh deliveries. Periodic examination of tanks by technical staff should be maintained and, when cleaning is found to be necessary, the inside surfaces should be completely freed from oil with steam and a suitable detergent. It is most important that the tanks and pipes be thoroughly flushed clean of all traces of detergent, and properly dried before refilling.

All pipelines should be installed with sufficient fall to allow easy and complete drainage. Since copper is a strong pro-oxidant, and contact with it will reduce the stability of an oil, the use of bronze fittings, such as valves and pump impellers must be avoided, steel being preferred.

Fresh oil should be discharged into an empty tank and not mixed with old supplies.

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- Loders Croklaan b.v., Wormerveer, Holland
- Frivessa b.v., Zaandam, Holland
- Witocan (Dynamit Nobel) D5210 Troisdorf, W. Germany
- Durkee Foods, Cleveland, Ohio

Milk products are major ingredients in the chocolate and confectionery industry and uses are described in many parts of this book. Milk chocolate is increasingly popular, and although milk powder is still used in great quantities in the manufacture of this chocolate, milk crumb is steadily gaining ground because of its quality and particular flavor.

In confectionery, sweet condensed milk and concentrated (evaporated) milk are used extensively. Reconstituted milk powders are also employed but special care in the preparation of their dispersions is needed. Whey products are finding increased use. Liquid milk is rarely used because of the large amount of water required for its evaporation but some companies claim that the best caramels are made from liquid milk. Many manufacturers use fresh cream.

Other milk products used in the industry are butter and butter fat (oil), lactose, and modified milk protein.

The confectionery technologist should know something of the properties and composition of the various milk products used in the industry and the following summaries should be of some assistance. For greater details about the various materials, reference should be made to the bibliography at the end of the chapter. Also, there are entire libraries concerned with the production of milk and milk products.

LIQUID MILK

Cow's milk is the dairy product in most countries but other milks are produced elsewhere. Buffalo milk, for example, is used in India and some Middle Eastern countries. Goat's milk is a domestic product in many countries.

Composition

The base components of all milk are described as fat, solids not fat (SNF), and water. The proportions vary considerably not only in

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Confectionery Processes and Formulations

The confectionery industry, like many others, has seen great changes in recent years. Basic formulations have altered little but the processes of manufacture have undergone many developments, particularly in the methods of forming small pieces and bars and their packaging.

It seems appropriate to summarize these changes at the beginning of this section and to discuss each application later with regard to particular formulations.

Certain groups of confectionery require particular methods of shaping so that they can be wrapped and packed in a manner most suitable for sale. Probably the most successful development has been the confectionery bar (also called candy bar). These bars lend themselves to economical methods of production, packaging, and presentation at the point of sale.

Concurrently, the improvement in packaging has been noticeable, with regard to both the material used and the method of sealing. Most candy bars require protective packaging to ensure good shelf life and to guard against damage by insects and extraneous contaminants. These factors are described in separate chapters.

Chocolate manufacture has already been discussed and it should be realized that chocolate and compound coatings are essentially fat based and any moisture present is very small—generally less than 1 percent. The ingredients are not in water solution.

Many confectionery processes utilize the special solubility properties of sugar (sucrose), alone or combined with others "sugars", such as glucose syrup (corn syrup) and invert sugar. There are basically two groups of sugar confectionery products: (1) those in which the sugars are wholly in solution, and (2) those in which the sugars are partly in solution and partly in the form of minute solid sugar crystals suspended in the solution. Other ingredients, such as milk and fats, may modify these products.

Group 1 includes hard-boiled sweets (hard candy), hard and soft caramels and toffees, and most jellies. Group 2 consists of such products as fondants, fudge, grained marshmallows, and grained nougats.

SUMMARY OF CONFECTIONERY PROCESSES

From the foregoing description, it can be seen that a variety of textures is obtained as a result of the various processes and formulations and each requires a particular method of forming into pieces or bars. These methods are summarized below but specific applications are described in other parts of the book.

Rolling and Cutting

This is probably the oldest method of producing bars and pieces, mostly from plastic products like caramel, fudge, nougat, and various pastes. The confection, in the right plastic condition, because of either its moisture, its fat content, or its temperature, is first fed through rollers to produce a slab of the required thickness. This slab is then fed to knife cutters to produce wide strips that are subsequently cut into narrow bars or small units. In a modern development of this principle, the hot product is fed to "iced" rollers, enabling the production of multiple-layered slabs. The slabs are continuously cut into strips that pass over a spreader and are then cut into bars or small pieces. An example of this process is the Sollich Conbar system (Fig. 19.1).

Casting or Depositing

This method is applied to hard candy, fondants, jellies, some caramels and fudge, marshmallows, and other products that can be obtained in a liquid state.

Fondants, Jellies, Marshmallows

These are usually cast into starch molds. The principle is described under "Fondants." More recent developments have been the automatic depositing and release of fondants and some other confections from metal molds (Cadbury-Baker Perkins) and the depositing of caramels and toffees into silicone rubber molds (Baker Perkins). Silicone rubber has unique nonstick properties as well as being resistant to the relatively high temperatures of high boiled confections.

Die Forming

This method is applied almost exclusively to hard candy and some caramels and toffee. It includes normal, flavored pieces, filled pieces (bonbons), and "pulled" candy.

Hard Candy

Certain types may be deposited as liquid at around 150°C (302°F) into metal molds the surfaces of which are coated with a "release agent."

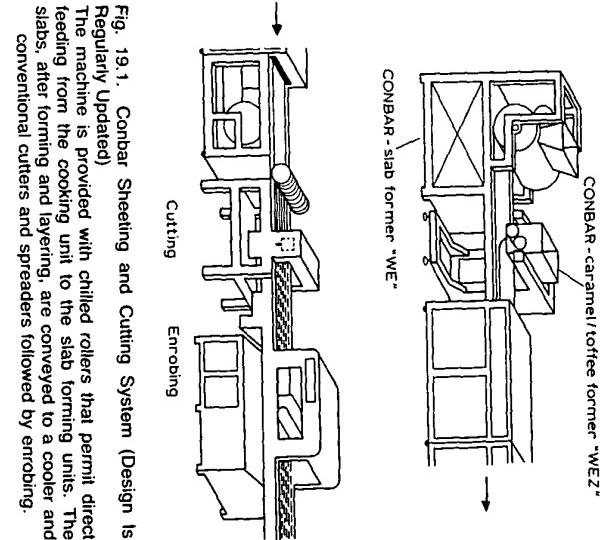


Fig. 19.1. Conbar Sheeting and Cutting System (Design 1s
Regularly Updated)
The machine is provided with chilled rollers that permit direct feeding from the cooking unit to the slab forming units. The slabs, after forming and layering, are conveyed to a cooler and conventional cutters and spreaders followed by erobing.

Sollich GmbH, Bad Salzuflen, West Germany

The principle is to cool the boiled syrup under controlled conditions until it is plastic. In this state, it is reduced to a "rope," which is fed to machined dies that press the rope into pieces that usually have some special form or pattern. These pieces are immediately fed to a cooler and a wrapping machine.

A modification of this principle is applied to certain caramels and chewy candy. Here the rope is similarly produced but it is fed to a cut-and-wrap machine, which, by means of a high-speed rotary knife, cuts small pieces off the rope. These are fed to the wrapping machine.

Extrusion and Bar Forming

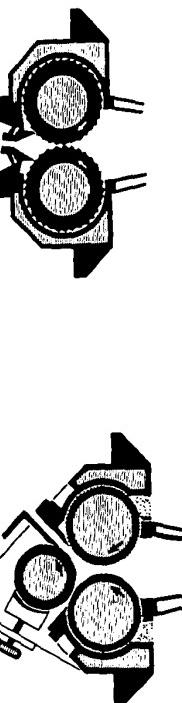
The principle of extrusion, developed for many nonfood products, has been applied very successfully in the confectionery industry. Altwater (1974), (Bepex-Hutt, Germany), has studied the application of the process to a variety of products, ranging from soft materials such as marshmallows and fondant to very plastic nougats and caramels. In the process, the material to be extruded is fed to the orifice by means of multiple rollers or screws. The cross-sectional design of the orifice determines the shape of the final unit and many extruders have a series of orifices producing ropes that can be cut into either bars or small pieces. Figure 19.2 shows the various designs used for extruders. Fig. 19.3 shows the cross section of a Werner-Lehara extruder with a mechanism for cutting small pieces from the ropes, and Fig. 19.4 shows a design by Weisert-Loser for the extrusion of chewing gum and chewable candies.

A somewhat different form of extruder is the N.I.D. Bar Former (Fig. 19.5). The fluted roller feed is similar to other extruders but the material to be formed is delivered to a second, channeled roller. The channels are Teflon coated to ensure easy release and are shaped to give the form of bar required. Fingers help to release the ropes onto a continuous belt.

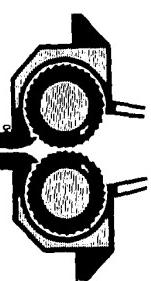
Multiple bars can be made in which two layers are extruded simultaneously. Alternatively, a bar with a center of a different confection can be made. Extrusion allies itself to other continuous methods of cooking and enrobing.

Certain precautions must be observed in the extrusion of confectionery:

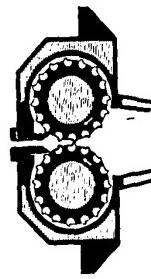
1. *Temperature.* The temperature of extrusion is critical, particularly with caramel and nougat where texture is closely related to temperature, and quite small changes can cause large differences in extrusion pressures. For a fairly soft caramel,



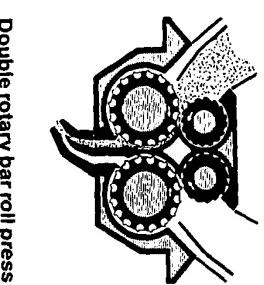
Smooth roller press



Toothed roller press



Double rotary bar roll press



Grooved roller press

Fig. 19.2. Rollers and Orifices for Extruded Products

Bepex-Hutt, Leingarten, West Germany

temperatures ranging between 35 and 38°C (95 and 100°F) are usual but obviously a lot depends on the type of product and the exact conditions must be determined by trial. Low temperatures and high pressures will cause the safety plugs, usually provided on extrusion machines, to be ejected.

Werner Candy Extruder - Side View

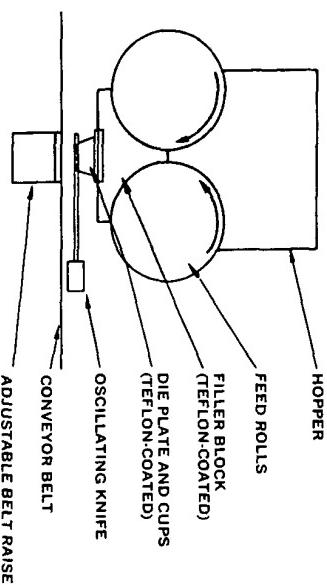


Fig. 19.3. Werner Candy Extruder-Side View

Werner-Lehena (Baker-Perkins), Grand Rapids, Mich.

2. **Fat separation.** If fat separates during extrusion, it is an indication of poor emulsification. Improvement is obtained by the inclusion of an emulsifier, such as lecithin or preferably glyceryl monostearate, in the recipe.
3. **Collapse after extrusion.** Some products lose their shape after extrusion and a strip of near-cylindrical cross sections may flatten appreciably after it has been on the belt for a short time. There are several reasons for this:
 - a. The moisture content is too high.



Fig. 19.4. Weisert, Loser Screw-Type Extruding Machine

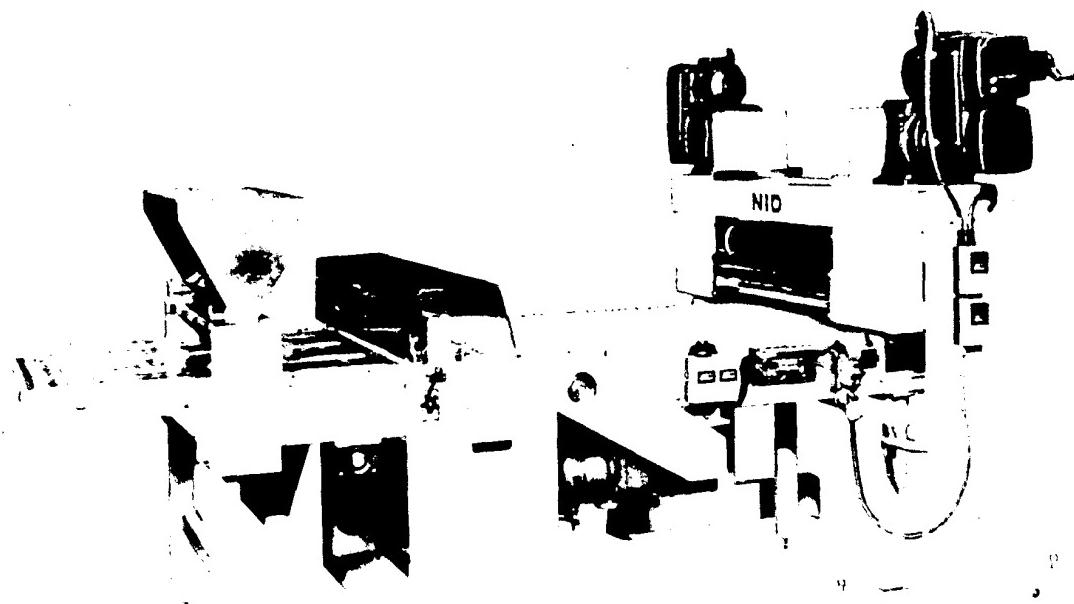
Weisert, Loser, Karlsruhe, W. Germany

Fig. 19.5. Bar Former

N.I.D. Pty Ltd., Alexandria, Australia

- b. The fat has not been emulsified and possibly is too soft.
- c. The protein of any milk ingredient is not properly dispersed.
- d. In fudge or pastes, the crystal structure has not formed or may have broken down by excessive mixing after forming the crystals. This can be a very elusive defect and in continuous fudge manufacture is related to the time at which the crystallizing fondant is added prior to extrusion. Only equipment will determine the optimum conditions for particular equipment. Companies specializing in extrusion equipment have done a great deal of research into the design of machines for extrusion of confections of different consistencies. For some products, such as chewable candies and chewing gum, the roller extruder has given way to the multiple screw extruder. These processes are described elsewhere in the book.

Panning

The principle of panning has already been described in the "Chocolate" section.

There are two kinds of sugar panning, hard panning and soft panning. In hard panning, successive layers of powdered sugar and syrup are built up on a suitable center (e.g., nuts) and dried off with warm air between applications.

Soft panning is carried out in a similar manner but is a cold process. Soft centers are used (e.g., pastes, jellies, soft caramel) and coating is with sugar/glucose syrup and powdered sugar. After coating to the correct size and weight, the pieces are partly dried and coated with a glaze.

The process has been fully mechanized, including the charging and discharging of the pans, the automatic spraying of the syrups (or chocolate), and control of the drying or cooling air supplied to the pans.

FONDANT CREME—BASE CREME

Confectioner's fondant made from sugar, glucose syrup (corn syrup), and invert sugar is usually spelled "creme" but some traditional products use the form "cream." This description would be incorrect in some countries.

Fondant is prepared by dissolving sugar and glucose syrup (or

invert) in water and concentrating by boiling to a solution containing about 88 percent solids. At ambient temperatures, this solution is supersaturated with respect to the sugar and is unstable, and if it is rapidly agitated and cooled, the excess sugar comes out of solution in the form of minute crystals. Thus, fondant creme has a solid phase of sugar crystals suspended in a liquid phase consisting of a saturated solution of "sugars."

Without agitation or cooling, large crystals will be formed. Beating alone is unsatisfactory as a large amount of latent heat of crystallization is evolved. If the beaten syrup remains hot, crystallization is retarded and subsequent slow cooling will result in the formation of large crystals. Good-quality fondant creme should be smooth in texture.

Originally, fondant was made using sugar only, which was dissolved in water and concentrated to about 88 to 90 percent solids by boiling. Since sugar has a solubility of only 67 percent at normal temperatures, a syrup at 90 percent was highly unstable, and when cooled rapidly, it crystallized, resulting in very coarse crystals.

To overcome this, a substance called a "doctor" was used, which caused inversion of some of the sugar. This increased the overall solubility and enabled the syrup to be beaten into a fondant creme.

The substances used as doctors were citric or tartaric acids or preferably cream of tartar ($\text{potassium hydrogen tartrate}$). The formation of invert sugar from sugar is discussed elsewhere in the book but, briefly, the doctors decompose part of the sugar (sucrose)—which, chemically, is a disaccharide—into two monosaccharides, dextrose and fructose. The fructose has a much greater solubility (approximately 80 percent at 20°C) than sucrose, and its presence with the dextrose enables the concentrated syrup to be beaten into a fondant.

This procedure of using a doctor is very unreliable as the amount of invert sugar produced varies greatly according to the purity of the sugar, the time of boiling, and the "hardness" of the water used. An improvement is possible by adding a controlled amount of invert sugar (prepared separately) to the sugar syrup.

Fondant prepared from sugar and invert sugar has a grained texture and is very sweet to the taste; it is rarely used in modern confectionery.

Glucose syrup (corn syrup) has replaced invert sugar in fondant recipes; it is less sweet and the presence of complex carbohydrates controls crystallization and gives a more viscous fondant without the short texture.

MANUFACTURE OF FONDANT

In the construction of a recipe for fondant creme, it is essential to include sufficient glucose syrup (corn syrup) to ensure that the final fondant has a syrup phase with a soluble solids concentration of not less than 75 percent at ambient temperatures, or microbiological troubles may arise. This condition is achieved by using a sugar/glucose syrup ratio of 80/20, and with a moisture of 12 percent in the fondant, the syrup phase concentration is over 75 percent.

Increased glucose in the recipe will give higher concentrations but it is not usual to increase the glucose ratio above 75/25 as crystallization is retarded during beating and the texture of the fondant suffers. Fondants with higher sugar/glucose ratios are manufactured for special purposes, such as the "graining" of fudge. Occasionally, fondant creams are made with up to 8/1 sugar/glucose ratio. These, because of the crystal structure, have a very short texture but also a limited shelf life.

The original hand method for making fondant consisted of dissolving sugar and glucose in water to produce a 75 to 78 percent concentration solution, for example,

Sugar	3.6 kg (8 lb)
Glucose syrup	1.0 kg (2.2 lb)
Water	1.27 kg (2.8 lb)

and this would have a boiling temperature of 107 to 109°C (225 to 228°F). This solution, which had to be free from all traces of undissolved sugar, was then boiled to 88 percent concentration at a temperature of approximately 117°C (243°F). This syrup was then poured onto a large, cold, marble slab and rapidly turned over and over, spreading at the same time. The cooling and agitation induced rapid crystallization and, understandably, the quality of the fondant depended on the skill and energy of the operator.

There are now two basic types of mechanical equipment for fondant manufacture. The first, which works on the batch principle, consists of a shallow pan with a water-cooled flat base. Rotating within the pan is a cross-arm fitted with plow-shaped paddles that turn over the concentrated syrup while it is being cooled on the base of the pan. This rapidly brings about the conditions for crystallization and a smooth fondant with fine crystals is produced. This type of machine is still used by many confectionery companies in the United States, where it is called a "Ball" beater. Although basically a batch machine, it has one advantage in that after the fondant is made recipe

- 1 Premix
- 2 Cooking
- 3 Cooling
- 4 Beating
- 5 First stage mixing - BOB
- 6 Second stage mixing - color and flavor

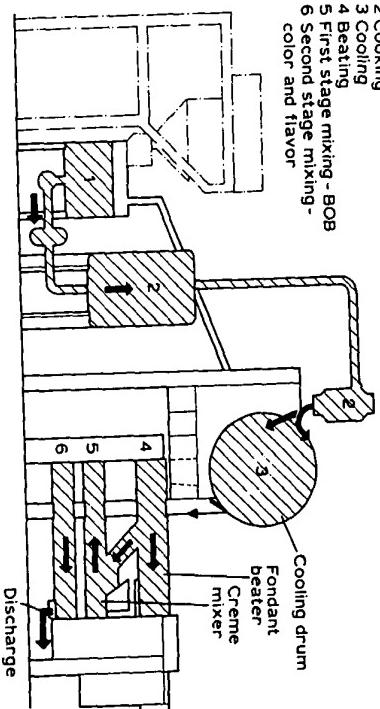


Fig. 19.6. Continuous Fondant and Creme Making

Baker Perkins, Peterborough, England

quantities of other ingredients can be added and mixed in the same machine.

The second type of machine is continuous with outputs of 453 to 635 kg (1000 to 1400 lb)/hr. In Figs. 19.6 and 19.7, two separate parts of the process are shown: fondant making and creme making. The latter provides for the inclusion of "bob" syrup, flavors, and colors, as is explained in the description of remelting.

Syrup is prepared according to one of the recipes previously mentioned. With large-scale modern production, the solution of the sugar and glucose is usually done by means of a machine called a continuous dissolver that takes the sugar and glucose from bulk storage, apportions them in recipe quantities with water, and dissolves and discharges to a storage tank that acts as a reservoir for feeding the cooker.

Continuous dissolvers work either on a volumetric or a weighing principle. The weighing method is considered more reliable, as with the volumetric method accuracy is affected by the bulk density of the sugar, and particularly by any lumps that may occur, although the latter is unlikely with bulk sugar supply. The prepared syrup is then supplied to the fondant-making plant.

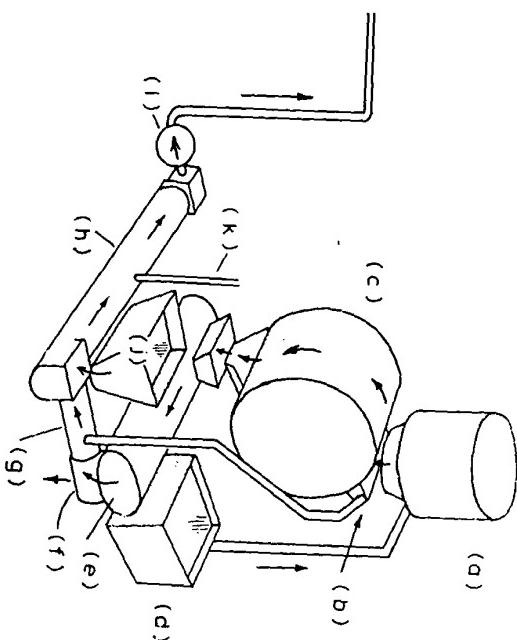


Fig. 19.7. Principle of Continuous Fondant and Creme Making

- a. Microfilm Cooker
- b. Bob Syrup
- c. Cooling Drum
- d. Syrup Storage
- e. Creme Beater
- f. Fondant Discharge
- for Remelting by Other Methods
- g. Mixing Tube 1
- h. Mixing Tube 2
- i. Frappe
- k. Flavor
- l. Discharge Pump

Baker Perkins, Peterborough, England

through a superheater that raises the temperature of the syrup before it is fed to a continuous cooker. The cooker may be of two types. One consists of a spiral into which the syrup is fed from the top and this spiral is surrounded by a high-pressure steam jacket that transfers heat to the descending syrup and evaporates the water that escapes as steam from the top of the cooker. The second type uses the principle of evaporating a thin film of syrup spread over a heated surface inside a cylinder, and the microfilm cooker is an example (See "Hard Candies.")

The concentration of the syrup is measured by the temperature of the syrup issuing from the cooker, and in modern installations automatic controllers are used where signals of temperature fluctuations are fed back to adjust steam pressure and syrup pump speeds. By this means, much more consistent results are obtained than by hand adjustment based on visual observation of a thermometer placed in the syrup at the cooker exit. The syrup at about 117°C (242°F) now has to be cooled continuously and this is achieved by dropping it from the cooker onto a large, slowly rotating metal drum, cooled internally by water sprays. The syrup is cooled from 117°C to approximately 38°C (100°F) during rotation through about 270 degrees, and by means of a scraper knife, this supercooled syrup is removed from the drum and discharged into a beater. No crystallization must occur on the drum surface during cooling and after the scraper fine jets of steam are applied to the drum surface to prevent any crystallization in the very thin residual film of syrup before it again meets more syrup from the cooker.

The beater consists of a square or cylindrical casing about 3 ft long and 1 ft 6 in. in diameter, fitted internally with metal pegs and provided with a cooling jacket with water circulation. Spindles, also with pegs, rotate in the casing and provide the beating action against the fixed pegs in the jacket. The internal design is such that the crystallizing fondant moves from the syrup inlet to the fondant exit, and an important point is to keep the beater full to get maximum effect from the beaters. This is obtained by means of an adjustable slide in the exit.

The quality of the fondant is largely controlled by the efficiency of the beater, which, in addition to bringing about rapid crystallization, must remove the latent heat by sufficient flow of water through the jacket.

The temperature of the fondant flowing from the beater must be less than 43.3°C (110°F) and maximum crystal formation should have occurred in the beater by mechanical action and cooling. If appreciable crystal formation occurs after beating, coarser crystals will form and the fondant will be rough.

Examination of fondant under the microscope should show an even distribution of sugar crystals, the larger ones ranging between 10 µm and 15 µm (0.0004 in. and 0.0006 in.). The presence of a proportion of larger crystals or uneven size distribution indicates inefficient operation of the beater—mechanical or cooling. Occasionally, the presence of small amounts of colloids, such as starch, gelatin, or egg, will retard crystallization. These may be present if syrup prepared

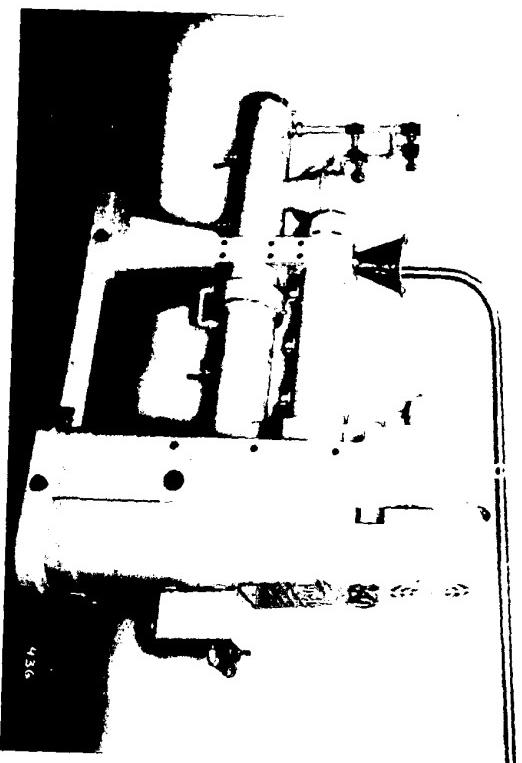


Fig. 19.8. Fondant Machine

Otto HänSEL, Hannover, West Germany

from scrap is included with the sugar and glucose ingredients. Syrup from scrap may give off-white colors, and in some circumstances, partial inversion of the sucrose—so special care in scrap reclaiming is required where fondant is concerned (see "Reclaiming").

Fondant machines are also manufactured as smaller single units. Syrup to be fed to these machines may be made separately in a kettle or by means of a continuous dissolver. This syrup is fed to a cooling tube followed by a beater provided with a cooling jacket. A machine of this type is made by Otto HänSEL (Fig. 19.8).

The Remelting of Fondant

Much argument has arisen in the past about the necessity of "ripening" fondant and the older confectionery makers always set aside their newly manufactured fondant in pans to mature. The

result was that a great deal of manual work was entailed in getting the fondant out of the pans again and into the remelting kettles. This practice persisted even when large continuous fondant equipment was introduced and much diplomacy was required on the part of the technologists to break down the prejudice associated with this practice.

The only support for maturing is probably when products known in the United States as hand-rolled cremes are required. This involves the process of extrusion or roller depositing where a particular texture is needed.

For the mass production of fondant centers, and particularly for chocolate shell centers, this break in the sequence of operations just cannot be tolerated. Much research has been carried out on the process of "remelting," which is necessary to bring the fondant into a fluid condition for mixing with flavors, colors, and other ingredients and to enable it to be poured into molds or chocolate shells.

The traditional process was to charge the fondant from the pans into steam-jacketed kettles provided with paddles and to heat the fondant to a temperature ranging between 57°C and 66°C (135°F and 150°F) with the addition of a syrup "bob." The bob was prepared as a syrup from sugar and glucose to the same recipe as the fondant, or occasionally with a higher proportion of glucose. At one time, it was the practice to make a low-concentration bob even down to 50 percent, but this is a dangerous procedure because, if the syrup is used to excess, the final fondant may become vulnerable to fermentation. A syrup bob should have a syrup concentration of 75 percent minimum and is best made with a sugar/glucose ratio the same as the fondant.

The temperature of remelt depends on the moisture content of the fondant, the ingredients, and the fluidity required at the pouring stage.

The process of remelting brings about a greater fluidity due to an increase in the proportion of syrup phase. This extra syrup phase is formed by some of the sugar crystals in the fondant going into solution or being partly dissolved and reduced in size.

The hot fluid fondant mixture when poured into molds or shells will cool and set. This is due to the growth of crystals of sugar from the syrup phase and an increase in size of crystals already there, the reverse of what has happened during melting. This increase in the number and size of the crystals results in some interlacing and gives the molded fondant a certain amount of rigidity, and with lower moisture contents a fracture appearance when broken.

When a fondant is remelted, the crystal size increase depends

partly on the speed of remelting and cooling and on the level of temperature reached. Temperatures over 65.5°C (150°F) will result in an appreciable increase in the syrup phase, and when this crystallizes, it will tend to give coarse crystals. However, if the final stages of remelting are carried out through a hot nozzle, higher remelting temperatures can be tolerated. Occasionally, a rougher, short fudge-like texture fondant may be required and remelting temperatures may be taken up to 74°C (165°F), but this is an exception.

The crystal size of a good assortment creme should range between 20 µm and 30 µm. Any significant proportion over 30 µm will make the creme taste rough.

Whatever the process for remelting fondant, it has now been shown to be quite unnecessary to mature it beforehand. Freshly made fondant may be taken and heated with flavors, bob syrup, and any other ingredients to remelting temperature and poured into molds or shells without any adverse effect on the quality of the product.

Continuous mixers have been devised to take fondant straight from the plant but this method is best used when high outputs of one recipe are required (Figs. 19.6, and 19.7). It is preferable in many instances to store the base fondant from the plant with or without bob syrup and for this purpose large water-jacketed tanks may be used with slowly moving mixing arms. The water in the tank jacket is thermostatically controlled at 49 to 54°C (120 to 130°F). The tank is covered and preferably provided with some ventilation to prevent excessive condensation on the lid. Under these conditions, storage periods up to 12 hr are possible with negligible crystal growth and the fondant may be drawn upon for kettle mixing with syrup, flavors, and other ingredients. For multicenter filled blocks made on shell equipment, the fondant from the tank is sufficiently fluid to be pumped through pipelines to a battery of kettles. Sometimes continuous circulation through pipelines between the storage tank and the kettles is used but some moisture loss from the fondant will occur with this system and this must be watched carefully otherwise hard-texture creme will result in the finished product and tails will form at the nozzles depositing the creme. The additional flow diagram (Fig. 19.9) is complementary to Figs. 19.6 and 19.7.

Frappe or whip is prepared by dissolving egg albumen or a substitute in water and then mixing with sugar/glucose syrup. This mixture is then beaten to a foam by means of a high-speed whisk, under either normal or increased pressures.

A great number of recipes have been proposed using different strengths of syrup and various quantities of whipping agent. It is left

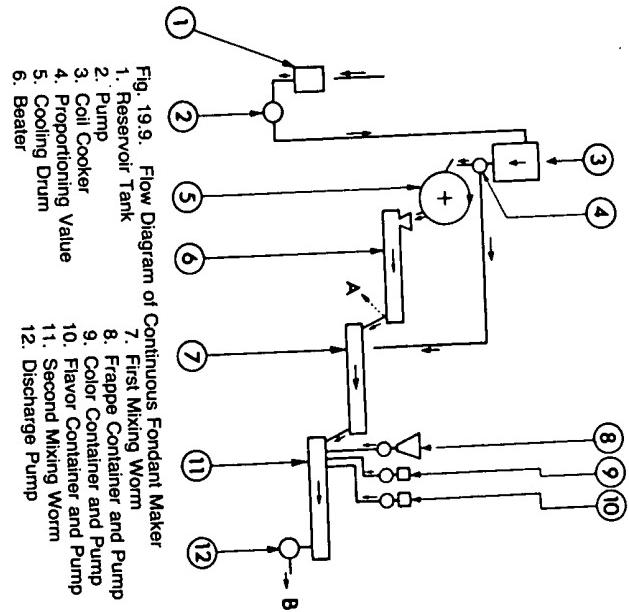


Fig. 19.9. Flow Diagram of Continuous Fondant Maker

1. Reservoir Tank
2. Pump
3. Coil Cooker
4. Proportioning Valve
5. Cooling Drum
6. Beater
7. First Mixing Worm
8. Frappe Container and Pump
9. Color Container and Pump
10. Flavor Container and Pump
11. Second Mixing Worm
12. Discharge Pump

Product removed at A requires further processing.
Product removed at B is ready for immediate use.

In this diagram it should be noted that uncrystallized bob syrup from the cooker (4) is bypassed to the first mixer (7).

Use of frappe: In the manufacture of creme centers for assortments or filled shells, certain recognized basic recipes are used in conjunction with the remelting procedure described above.

If the remelted fondant, with flavors and colors, is allowed to set, the result is normally a rather dense product and a lighter texture is obtained by the inclusion of "frappe."

Baker Perkins, Peterborough, England

to the technologist to work out recipes to give the required texture in the finished product and the following are typical examples of an egg and substitute frappe.

Egg Frappe	Egg albumen	113 g (4 oz)	Soak in a cool place for 24 hr and pass through a fine sieve.
	Water	213 g ($\frac{7}{2}$ oz)	
	Sugar	2.26 kg (5 lb)	Dissolve and boil to 107.2°C
	Glucose syrup	3.17 kg (7 lb)	(225°F)
Water		1.12 kg (18 oz)	

Allow the syrup to cool to 60°C (140°F) and then add the egg albumen solution and whisk. The density of this foam or frappé is of the order of 0.35 to 0.5, and as it has limited keeping properties, it should be used in fondant within a few hours.

It is advisable to pasteurize egg syrups before whipping, details are given under "Egg Albumen."

Hyfoama is a widely used proprietary whipping agent and the following recipes are given in the technical handbook.

Frappé for Standard Beater.

Hyfoama DS

99 g (3½ oz)

Water

1.36 kg (3 lb)

Icing sugar

2.26 kg (5 lb)

Sugar

6.35 kg (14 lb)

Water

1.80 kg (4 lb)

Glucose

12.7 kg (28 lb)

Mix and beat to a stiff foam.

Add to the boiled sugar batch and

then add this mixture to the foam

and beat again to a stiff foam.

Frappé for Pressure Beater.

Hyfoama DS

99 g (3½ oz)

Water

1.98 g (7 oz)

Glucose

0.45 kg (1 lb)

Sugar

8.6 kg (19 lb)

Water

2.72 kg (6 lb)

Glucose

12.2 kg (27 lb)

Mix Hyfoama and water.

Add glucose, mix well.

Boil to 111°C (232°F).

Add to the boiled sugar batch and

then add this mixture to the

Hyfoama dispersion and beat for

3 min at 30 lb/sq in.

Machinery for the Manufacture of Frappé

Frappé is not only used in fondant, it is also used in nougat, fudge, marshmallow, and wherever a lighter texture is required.

Normal Beater.

For small batches, the vertical planetary beater such as the Hobart whisk may be used, but for larger batches, "U" troughs with horizontal beaters are sometimes employed.

Pressure Whisks

These make use of the principle of whisking the syrup and aerating agent in a hermetically sealed bowl, the ultimate density of the frappe depending on the quantity of syrup and the air pressure in the bowl. In this type of machine, the air pressure is used to discharge the frappé that is ejected through a valve and pipe at the bottom of the bowl. An example of this machine is the Morton Pressure Whisk (see "Marshmallows").

This is necessarily a batch process but for very large production continuous pressure beaters are available. A solution of the whipping agent in syrup is prepared batchwise or by metering the ingredients into continuous dissolvers, and this is brought to a standard temperature in a storage tank prior to the beater. From this tank the syrup is fed into the pressure whisk at a standard rate, together with a measured supply of air or an inert gas such as nitrogen under a given pressure. The aerated batch is discharged continuously through a back pressure valve and its density is controlled by the rate of feed of syrup and air. The Oakes machine works on this principle. In continuous equipment using egg or gelatin syrups plant sanitation is of paramount importance. Residues in pipelines, pumps, etc., can be breeding grounds for all types of microflora. Planned cleaning and sterilization are essential and detachable pipelines are advantageous. This is discussed in the microbiological section.

Hyfoama frappés are stated to have good stability but they are best used within 24 hr of making. More recently, developments in the United States with soya protein isolates have resulted in the production of whipping proteins with certain special advantages over egg and milk protein products. Details of these are given under "Whipping Agents." Some confectioners use these newly developed whipping agents as partial replacement of egg albumen.

The terms "whip" and "frappé" are sometimes used to qualify the density of the product, whips usually being of lighter density with short keeping properties, whereas frappés are of greater density with more syrup and will keep longer.

Whip and frappé may be used in fondant bases in varying quantity depending on the ultimate density required. 7 to 10 lb per 100 lb of

Fondant Remelting

Some reference has already been made to fondant remelting. The most flexible method uses steam-jacketed pans working on low steam pressures (20 psi). These pans may be up to 500 lb in capacity and

must be provided with slowly moving mixing paddles that sweep the sides of the pan continuously. The motion of the paddles must also give some vertical movement within the mass. A number of manufacturers of confectionery machinery supply pans for fondant remelting.

It is important in this process to ensure that thorough mixing is obtained in the minimum time and this applies particularly when frappé is used. Prolonged mixing or mixing at high speed will cause aeration loss and variation in density.

Kettle Process for Fondant Remelting for Cast Cremes

Cremes to a variety of recipes may be prepared for casting into starch molds, chocolate shells, or, more recently, into metal, plastic, or rubber molds.

When using fondant from a storage tank, the following is a typical process. The recipe quantity of frappe is added to the remelting pan. Fondant from the storage tank is then added, with intermittent mixing, until the recipe amount is reached. About half of the syrup bob is then mixed in and the temperature of the mix raised to the remelting temperature: 60°C, 63°C (140°F, 145°F) or as required. Further bob syrup is then added to give the right fluidity, followed by flavors, colors, and acid solution. If invertase is used, this must be added as late as possible prior to casting the batch and the fondant temperature must not exceed 65°C (150°F). (See "Invertase.")

If jam or concentrated fruit pulps are used as ingredients, these will cause appreciable thinning and may increase the syrup phase to such an extent that coarse crystallization (graining) may occur during cooling after casting. In such cases, the syrup bob may not be required, or at least be reduced in quantity. When fruits or pulps are added, care must be taken to see that the syrup phase concentration is not reduced to below 75 percent and it is always safer to make these into a jam or conserve with sugar and glucose syrup, also to a minimum concentration of 75 percent.¹

The same applies when adding chopped, preserved fruit or candied peel to a fondant. Frequently, preserved peels and fruit as purchased have a syrup phase concentration of about 70 percent and if used in this form, the pieces can provide sites for microbiological activity in

the finished product. Such fruit should be heat treated in higher concentration syrups (see "Preserved Fruit").

From time to time, proposals are made to include various gelatinous or colloidal ingredients in fondant creme, either at the remelting stage or in the syrup before boiling and beating. The author's opinion is that claims for these additions are usually exaggerated. Colloidal substances added at the syrup stage retard crystallization in the beater. Gelatin, agar, or starch syrup included during remelting will produce a "set" in the cooled creme and this is not necessarily an improvement. Certain essential oil flavors may have a destructive effect on the aeration introduced by the frappe and some may deteriorate from oxidation (see "Marshmallows").

Casting Cremes in Starch

The basic process for many years for the manufacture of cremes for chocolate centers or for crystallizing has been the depositing of liquid fondant (prepared as previously described) into hollow impressions in trays of cornstarch. These trays, which are normally 32 in. × 16 in. and about 2 in. deep, are filled loosely with cornstarch, known commercially as molding starch. Although pure cornstarch can be used, better impressions are obtained with "oiled" starch and this consists of the same cornstarch impregnated with about 0.05 to 0.10 percent of purified mineral oil (medicinal white oil). It is also a fact that "used" starch will take an impression better than "new" starch, due to sugar residues from confectionery causing the starch particles to cling, and most factories use unoiled starch to make up production losses until complete replacement is required.

The filled starch tray is "printed" by means of a rigid flat board or metal plate to which are fixed rows of protrusions that represent the shape of the hollow impression to be made in the starch and ultimately the shape of the cast creme. The protrusions are often called "pips" and are made of plaster, wood, or metal. To prevent starch from adhering to them when pressed into the starch, they may be polished with graphite. The spacing of the pips and the quantity of starch in the tray are such that when the printing takes place displacement of the starch is just sufficient to give clean impressions and a level top surface. An important factor in this process is the moisture content of the starch, and in order that the cast creme after cooling can be removed from the trays of starch, the outer layer of the creme must be fairly rigid and this is brought about by the passage of moisture from the creme to the starch.

¹ Note—75 percent concentration means the syrup phase concentration of soluble solids as determined by refractometer. This is discussed under "Microbiological Problems."

Under normal factory conditions, the equilibrium moisture content of molding starch is between 12 percent and 14 percent and this will give bad surfaces to cremes that are poured into it—it may even result in starch adhering to the surface of each unit, which greatly detracts from eating quality. For pouring of most fondant cremes, the moisture content of the starch should be between 6 percent and 8 percent and under these conditions the cremes are removed from the starch in 5 to 8 hr provided they are cooled adequately during that period. These conditions give a firm surface to the cremes.

It is also possible to pour cremes into starch with a moisture content of 9 to 11 percent where overnight storage (16 hr) is required, but this gives a slightly different texture. The former method is preferred, particularly with cremes containing a high proportion of frappé or jam, pulp, and other hygroscopic ingredients. As a result of considerable experimental work, the conditions shown in Table 19.1 have been utilized successfully.

The alternative conditions were used depending on the circumstances of labor, planning, and the nature of the center. Item 1 in the table is interesting. Here the cast fondant was raised to a higher

TABLE 19.1. EFFECT OF MOISTURE CONTENT OF STARCH WHEN CASTING CREMES

Type of confection	Starch moisture content, %	Air conditions	Time of removal after casting, hr
1. Straight fondant center, No frappé, essential oil flavors only	10-11	55-60°F 55-60% RH Moving air between trays	3-4
2. Fondant with frappé, essential oil, or synthetic flavor. Some creme containing jam or pulps	6-8	Ambient temperature 55-60% RH air movement by convection only	5-8
3. Fondant with or without frappé, essential oil, or synthetic flavor. Some cremes containing jam	9-11	Ambient	16-24 Have been left over weekends
4. Very light fondants, marshmallows	4-6	Ambient	6-16 depending on recipe

remelting temperature—74°C (165°F). The cremes in starch were cooled with moving air and setting took place with little loss of moisture. The cremes had a short texture with a larger sugar crystal than normal.

The temperature of the starch into which the cremes are cast is important. The starch must be correctly dried but not hot or the deposit may sink into the starch, causing starch crusts. The optimum temperature for cremes is 30 to 32°C (85 to 90°F). This does not apply to certain gums or jellies of lower moisture content where hot starch and heating in a stove are used.

It is also possible to store certain cremes for a limited period, using method 2, after they have been removed from the starch. The conditions found most suitable, with the cremes stored in shallow layers in ventilated trays, were 18.3°C (65°F) and 65 percent relative humidity. Under these conditions, slight drying occurred on the surface and this prevented the cremes from sticking together.

Control of the condition of cremes and other centers poured into starch for supply to enrobers that are also receiving a variety of other centers, such as caramels, jellies, and fudges, is no easy task. Neither is it a simple matter to control the moisture content of the starch into which they are poured. These problems are discussed in the following section on machinery.

Machinery for the Casting of Confections in Starch

It was not many years ago when the production of all confectionery centers was by hand or semi-mechanical methods. They are worth description because they are still widely used in experimental confectionery workshops. The sequence of diagrams (Fig. 19.10) illustrates the methods employed and which have now become mechanized.

The first useful advance in mechanization was a machine that printed the tray of starch and moved this, on a short chain conveyor, to a multiple depositor fed from a hopper that was kept supplied with hot remelted creme. The depositor, working on the piston principle, supplied precise quantities of liquid creme to each starch impression. The starch trays were fed by hand to one end of the machine and, after filling, the rows of impressions from the depositor were removed manually from the other end and stacked to allow the cremes to cool and set. The cremes in starch, after setting, were removed and brushed free of loose starch in another machine, which also refilled the empty trays with starch. A rotary sieve was sometimes fitted to

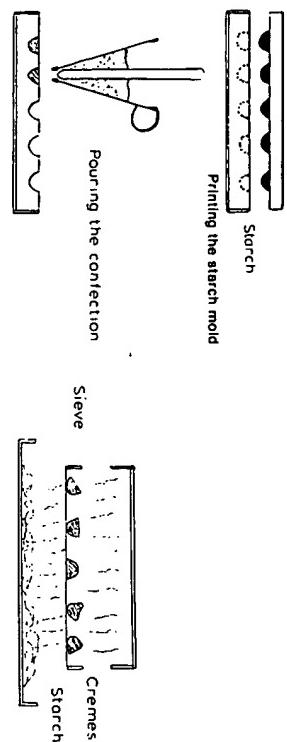


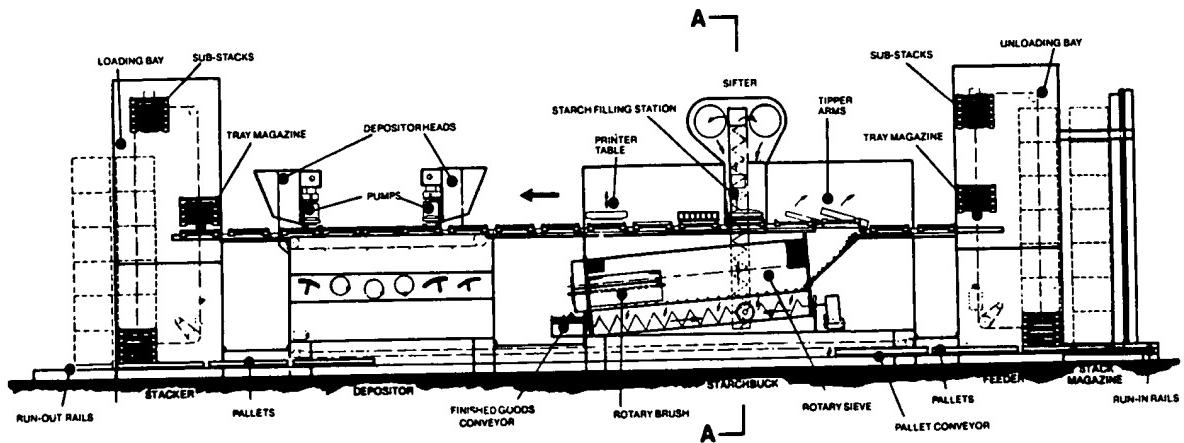
Fig. 19.10. Hand Casting Cremes in Starch
For hand pouring, the deposit is obtained by raising and lowering the tapered stick. After cooling and setting, the cremes are removed by sieving.

this machine to remove coarse tailings of creme from the starch before filling into trays.

To dry the starch, the filled trays were stacked in a hot room until required for use. They were removed from the hot room some time before they received creme deposits. Dry, but not hot, starch is required for creme centers.

In some factories the method just described is still used, but in large plants, the sequence of events has been fully mechanized in an ingenious machine known as a Mogul (Figs. 19.11 and 19.12). This machine accomplishes the following.

1. It receives a stack of trays containing starch with its content of cooled and set centers—deposited previously.
2. It de-stacks the trays one by one and feeds them into the first section of the machine, which inverts them over a vibratory sieve.
3. The vibratory sieve allows the starch to pass through the mesh and the cremes travel along the sieve where they meet oscillating brushes that remove most of the adhering starch. These cremes are then fed out of the machine into trays or onto conveyors where they are taken to the enrobers for chocolate covering or crystallizing. Before the enrober, the remaining starch dust adhering to the creme is removed by an air-blowing and extraction device. (A modern development in which the cremes are fed directly to the enrober is described below.)
4. The starch is then conveyed automatically to the recirculating plant where it first passes through a sieve to remove creme particles and then to the drier (described later).



N.I.D. Pty., Alexandria, Australia

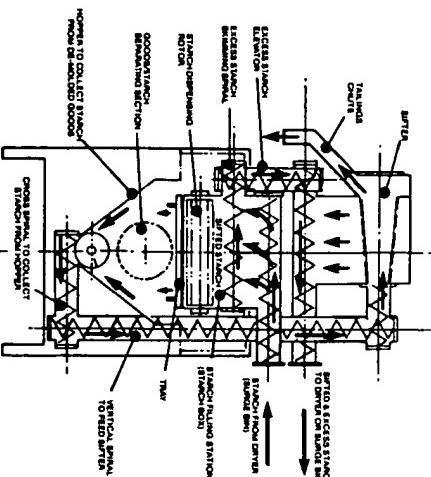


Fig. 19.12. Cross Section A-A with External Starch Conditioning System

6. These filled trays then pass beneath the printer, which is the board with pips affixed, and this works in unison with the filled trays moving forward toward the creme depositor.
 7. The trays of starch with impressions move beneath the row of depositors and by synchronization of motion a row of creme deposits, which can be as many as thirty to forty depending on the size of the unit, are delivered into the impressions.
 8. These trays of warm liquid deposits are then stacked automatically and taken to the cooling room.

The starch conditioner may serve more than one Mogul and the dried starch is sometimes used as a partial makeup of the total starch going through the Mogul circuit, but the latter procedure is best avoided unless adequate mixing is ensured.

To heat and dry the starch at regular intervals is a decided advantage from a microbiological standpoint. Yeasts, molds, and bacteria can accumulate in starch repeatedly in use and the intermittent heating and drying greatly reduce the viability of these organisms.

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The Pneumatic Starch Buck (Fig. 19.14)

A new development eliminates the need to transfer manually to the enrober conveyor confectionery pieces collected in trays after sieving. The sequence of operations is as follows:

1. The tray filled with molding starch and the deposited articles is positioned beneath a tightly fitting cover.
 2. The tray and its undisturbed contents are then transferred by a unique mechanism onto a mesh conveyor belt. During this process, there is no movement between the tray, its contents, or the transferring bed or conveyor.
 3. The tray is lifted cleanly off the contents, reinverted, and placed at the entry of the starch-filling section. Trays are then refilled, leveled, printed, and transferred to the depositor.
 4. The starch is now loosened from the articles (which remain in their same orderly position) by fast-rotating, compressed-air jets. The fluidized starch is drawn into the starch conditioning and recirculating system.
 5. The product, now freed of the main body of starch, is conveyed to a final cleaning stage where any residual starch is removed from all surfaces of the articles by fine rotating jets of compressed air.
 6. The goods, still in the same positions, upon passing out of the end of the buck, are turned for transfer to the enrober conveyor.

Some Moguls have built-in driers that use higher temperatures, and an airlift and cyclone system. Starch driers constitute a considerable explosion hazard and some serious accidents have occurred. It is wise, therefore, in any starch-drying installation to observe government recommendations regarding spark-proof switches, blast

walls, relief vents, and smother grit containers. Dust explosions very often start as a very minor incident that disturbs powder in trays, on ledges, and elsewhere. This initiates a major explosion and the precautions mentioned are designed to confine the explosion to the first minor event.

A modern development in starch drying is claimed to reduce the risk of explosion and economizes in heating. It is a fluid bed drier and cooler of modular design that can be integrated into any Mogul system.

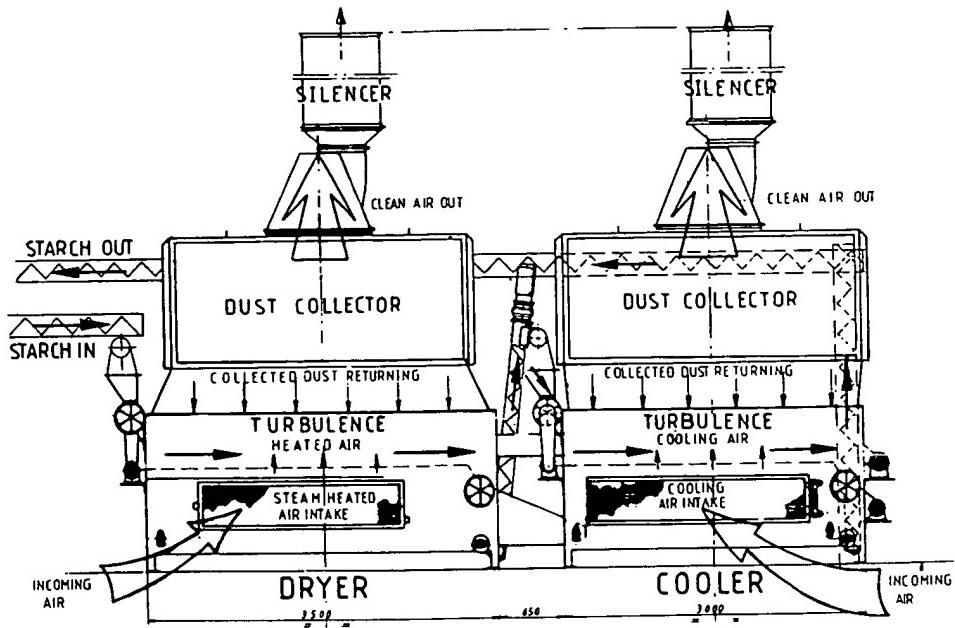


Fig. 19.13. Diagram of the Vortex Aeration Starch Conditioner
The Vortex closed circuit system can be added to any Mogul for aeration conditioning of starch at throughputs from 8,000 to 10,000 Kg per hour (17,600–22,000 lbs).

N.I.D. Pty., Alexandria, Australia

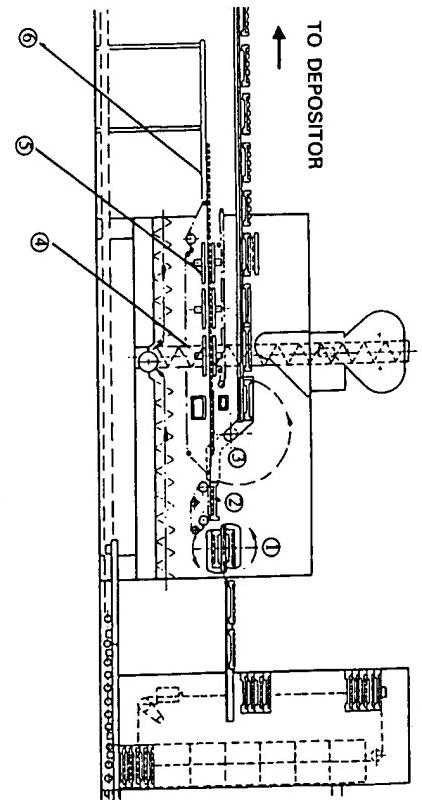


Fig. 19.14. Pneumatic Starch "Buck"
Depositor section similar to that shown in Fig. 19.11.

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This system permits the handling of fragile pieces such as sugar crust liqueurs that is not possible with the original starch-removal system.

Some Mogul depositors are able to deliver two types of confection, either as two separate deposits or as a multiple deposit with one material inside the other. The second system is very useful for jam-filled cremes. Nuts, cherries, or other pieces may be placed by hand or mechanically in the starch impressions, which then receive a deposit of creme.

The Mogul depositors consist of V-shaped hoppers provided with hot water jackets and a coarse tray sieve is fitted over the top to hold back any foreign matter or lumps.

They are kept filled from the remelting system.

Besides the large variety of fondant cremes, many other types of confectionery can be poured into starch molds provided the recipe is designed to set by cooling and partial drying. These include jellies, nut pastes, marzipans, Turkish delight, soft caramels, fudges, marshmallows, and many gums and pastilles.

With creme, texture is important and overdrying is a mistake too often made. It generally occurs as a result of leaving the pieces in starch too long due to bad production planning or perhaps because of machine breakdown.

TABLE 19.2. MOISTURE CONTENTS OF DIFFERENT FONDANT FORMULATIONS

Conditions shown in Table 19.1	Type of confection	Normal moisture content, %
1.	Straight fondant center, no frappé	10.5-11.5
2.	Fondant with frappé, essential oil, or synthetic flavor	11.5-12.5
3.	Fondant with or without frappé Cremes may contain some jam	11.0-12.0

Moisture contents should be maintained within fairly narrow limits—cremes much below 10.5 percent are generally too hard, and at 13 percent and over are difficult to handle mechanically and may be subject to fermentation.

Under the time/temperature/starch moisture conditions shown in Table 19.1 those shown in Table 19.2 may be expected.

Advantages of the Mogul System

Criticism has been leveled at the system because of the quantity of starch powder in circulation, which leads to a very dusty environment. There is difficulty in maintaining good sanitation within the machine and the starch itself may develop a high microbiological count. However, improved design and good housekeeping reduce these problems to a minimum.

The Mogul and starch printing operation allow for the rapid change of product being produced. The replacement of the printer and depositor can be done very quickly. The printer is not an expensive piece of equipment.

Starch casting also produces a dry skin on the units being deposited. This helps in the handling of the pieces, gives an interesting internal texture, and, in some cases, allows a formulation to be used that is not possible when rubber or metal molds or extrusion methods are employed.

Dextrose Fondant

The chemistry and physical properties of dextrose are described in Chapter 8.

Dextrose monohydrate has found increasing uses in confectionery processes of recent years.

Apart from its lower sweetness than sugar, its unusual crystallization properties can be of value or an embarrassment in certain processes.

Syrup mixtures containing a high proportion of dextrose will, on standing and cooling, deposit crystals. If the syrup is not seeded, these crystals will be in the form of nodules, but if seeded, they will be in orientated needle form, which gives an objectionable waxy texture.

Mechanical beating of this crystallized product will result in the breakdown of orientation and a smooth fondantlike product is formed that will deposit in chocolate shells and become only slightly more set on standing. It will not return to the waxy rigid texture.

The exact final texture of a dextrose fondant depends on the proportion of dextrose, the degree of mechanical mixing, and the amount of crystallization that takes place after the fondant is poured.

In some chocolate shell plant recipes, it is desirable to have a fluid recipe for pouring at a temperature below the melting point of chocolate but that has a nonfluid texture after storage for a short period when the shell is complete and demolded. The exact proportions of dextrose depend on the nature of the confectionery center, and the best way to add the dextrose is in the form of frappé as follows:

Dextrose monohydrate	45.3 kg (100 lb)
Glucose syrup (low conversion)	45.3 kg (100 lb)
Water	10.4 kg (23 lb)

Boil to 104°C (220°F). Cool to 52°C (125°F). (Note. This temperature is critical.) Then add egg albumen 1.8 kg (4 lb) and water 4.5 kg (10 lb) previously soaked, dissolved and sieved.

This mixture is "seeded" by continuous stirring, followed by beating to the required density. Alternatively, it may be added to the final product after "seeding" and then beaten. In many cases it will be found that the addition of 5 to 10 percent of frappé will give the desired texture to the final fondant.

Dextrose frappé is not recommended for use in high-temperature shell plant deposits where special cooling facilities are available to prevent the remelting of the chocolate shell.

In fondants with high dextrose contents the following base syrup may be used in conjunction with frappé:

Dextrose monohydrate	20 kg (44 lb)
Glucose syrup (low conversion)	11.3 kg (25 lb)
Sugar	9 kg (20 lb)
Water	5 kg (11 lb)

Dissolve by bringing to the boil. Then cool to 30°C (85 to 87°F).

Cream by adding about 2 percent of a previously prepared fondant or seeded dextrose syrup, and allow to stand undisturbed for at least 16 hr.

This solution will then have set to a stiff paste and this may be beaten with dextrose frappé, flavoring materials, and some bob syrup, if necessary, until the desired fluidity is obtained.

Dextrose fondants are not easily prepared and some experimenting is necessary.

CARAMELS, TOFFEES, BUTTERSCOTCH, FUDGE

These confections owe their character mainly to the presence of milk, butter and certain vegetable fats.

Milk solids, when heated in the presence of water and sugars (sugar, invert, glucose), develop a characteristic flavor due to the reaction between the milk proteins and the "reducing" sugars. This is known as the Maillard reaction and is described as a particular kind of "caramelization." Caramelization of a different type also occurs in sugar, glucose, and invert sugar when syrups are boiled to temperatures of 149 to 157°C (300 to 315°F). A stronger type of caramelization with yet another flavor is obtained by alkaline treatment, for example, by the reaction of sodium bicarbonate with boiling syrup at about 300°F.

The action of ammonia on certain reducing sugars also gives "caramel color."

Butter when added to high boiled syrup is subject to some decomposition and gives a characteristic and attractive flavor. No vegetable fat used in its place gives the same result, although certain fats have been developed that go some way toward attaining the butter flavor.

Brown sugars, golden syrup, and molasses have a flavor that goes well with caramelized milk and these sugars are used a great deal in caramel recipes.

The flavor produced by heating milk solids with sugars is related to the method and time of cooking and on this point great arguments have arisen with the introduction of mechanization. Continuous processes for caramel cooking invariably resulted in loss of caramel flavor compared with batch processes. However, this lack of flavor was overcome by the introduction of "caramelizers" where the continuously made caramel is held at just below cooking temperature in containers with slowly moving paddles until the extra flavor has

developed. The process is still continuous, there merely is more caramel in the system.

The distinctions among caramel, toffee, and butterscotch are those of milk and fat contents, the type of fat, and the moisture content determined by degree of boiling. There are soft and hard caramels, toffees are usually hard and slightly chewy, and butterscotch is hard and brittle.

Continuous cooking and lack of flavor may be an advantage if fruit- or mint-flavored caramels are produced. With these, excessive caramelization will overrule the delicate flavors.

In all the products described above, the sugars are wholly in solution in supersaturated form with the fat and milk solids fully dispersed.

Fudge, however, and certain "grained" caramels resemble fondant and a proportion of the sugar in the form of small sugar crystals is dispersed in the remaining syrup with the fat and milk ingredients.

The Milk Ingredient

The properties and composition of milk products are discussed in a separate chapter. Their behavior in caramel manufacture is closely related to the condition of the milk proteins and dispersion of the milk fat. Changes do occur in processing liquid milk into condensed milk or milk powder.

Liquid milk is rarely used for caramel manufacture, mainly because of the large amount of water to be removed. In the manufacture of evaporated milk, this water is more efficiently removed by multiple-effect evaporators.

If liquid or evaporated milk is used for caramels, stabilizers in the form of sodium carbonate (or, where permitted, sodium phosphate or citrate) are added. This raises the pH to a level above the coagulation point (isoelectric point) of the milk protein.

The pH of fresh milk will drop from about 6.5 to 4.5 as it ages and sours. At the lower pH, the protein rapidly precipitates on heating (curdling).

Sweetened condensed milk is favored by most caramel manufacturers and it can be either whole or skimmed.

Whole sweetened condensed milk contains the milk fat that adds to flavor, but sweetened skinned condensed milk makes good caramel and vegetable fats with suitable emulsifiers can be used in place of the milk fat. Whole and skinned milk powders are also used, but it is essential to make sure that the powder is properly dispersed before

being incorporated in the caramel boil, or rough particles will appear in the finished product and the caramel will lose a lot of its "stand-up" properties due to incomplete dispersion of the protein.

The recipes for these reconstituted milks may be tailored to suit the caramel being made and it is advantageous to incorporate in the milk the entire vegetable fat ingredient of the caramel followed by good emulsification. It is useful to make these reconstituted milks with a higher moisture content than standard condensed milk. They emulsify better, and it aids the solution of milk powder and assists the caramel boiling.

Reconstituted milks with high moisture content must not be stored as they will be susceptible to microbiological deterioration. There are various procedures for milk powder reconstitution but a spray-dried powder of good solubility always must be used, whether whole milk or nonfat milk. Roller process powder is not satisfactory.

Reconstitution of Milk Powder

The following is a typical recipe and process:

Water	25 kg (55 lb) (35 kg (77 lb) alternative)
Nonfat-milk powder (spray process)	22 kg (48.5 lb)
Sugar 32°C approx.)	45 kg (99 lb) 8 kg (17.5 lb)
Vegetable fat (melting point or increased amount depending on caramel recipe)	400 g (14 oz) 100 g (3.5 oz) (or an amount to give pH 6 to 6.5)

RECIPES, PROCESSES, AND EQUIPMENT FOR CARAMEL, FUDGE, AND TOFFEE MANUFACTURE

Mix vigorously the water (cold), milk powder, and sodium bicarbonate. Then add the sugar and continue to mix while heating to not more than 70°C (158°F).

The fat is melted and lecithin dispersed in it. This is then added to the milk/sugar portion and again well mixed to a temperature of 70°C.

The mixture is then put through an emulsifier or colloid mill to ensure complete dispersion. This mixture contains a high proportion of water, especially if the higher recipe amount is used. It should be

used within 24 hr. Utensils or equipment used for this product must be thoroughly washed and sterilized after use.

Fats

The true confectioner maintains that there is no replacement for butter in toffees and caramels, and from a flavor standpoint this is certainly the case. It will also emulsify more readily than vegetable fats.

Nevertheless many good caramels are made with vegetable fats and for many years the recognized toffee butter was hardened palm kernel oil, but with the uncertainties of fat supplies and prices, many other vegetable oils are now used. These are described under "Confectionery Fats." Most fats now purchased are well refined and it rests with the user not to spoil them by overheating during melting. This reduces their stability and may cause oxidative rancidity later. Heating the fat alone in the presence of copper will accelerate rancidity yet it is a remarkable fact that in caramel boiling with the sugars present copper pans are used successfully. However, carefully controlled tests using copper and stainless-steel gives a product with superior shelf life.

Sugars

The properties of the various types of sugar are described under "Confectionery-Sugars." The brown sugars and syrups are used in caramels to give additional flavor and can be added to replace some or all of the white granulated sugar as required.

Lecithin
Sodium bicarbonate (or equivalent
sodium phosphate)

There are numerous variations in caramel formulation and these are determined by cost and quality requirements. The best-quality caramels have, as a rule, higher milk solids and fat content. The following experimental recipe is an example of a good quality soft caramel. For students of confectionery, the preparation of this caramel in a gas-fired pan with mechanical stirrer is a good introduction to the manufacture of this very popular confection. The

experiment can be extended to include variations in some of the ingredients and to the making of fudge.

Water	3 kg (6.5 lb)
Sugar, white, granulated	4.5 kg (10 lb)
Sugar, brown	4.5 kg (10 lb)
Glucose syrup (42 DE)	7.7 kg (17 lb)
Full fat sweetened condensed milk	8.2 kg (18 lb)
Hardened vegetable fat (melting point/50°F, 32°C)	3.6 kg (8 lb)
Glyceryl monostearate	227 g (8 oz)
Salt	142 g (5 oz)

All the ingredients are placed in the pan and the mixer set in motion. The gas fire is lighted and heating continued on a low flame until the sugar is dissolved and the ingredients are completely mixed. Any sugar or other solids that may have accumulated on the sides of the pan above the liquid level are removed by means of a wet brush (after stopping the mixer). Heating and mixing proceed with the heat increased and the mixture boiling steadily. The level of heating will be obtained by experience, fierce heat will produce scorching on the pan surface and cause dark particles to appear in the mixture. The degree of boil is determined by hand thermometer, which should be kept in hot water before use. The heat is lowered, the mixer stopped, and the thermometer moved quickly through the caramel until the temperature is constant. Boiling is continued and the testing repeated until the thermometer registers 118°C (245°F). The fire is turned off, mixing continued for a few minutes, and then the caramel is discharged on to a cooling table.

Note the following: Change of color during heating.

Experiment 1. Sometimes caramels become overcooked and it will be noted how rapidly the temperature rises after 245°F. In the first boiling above, a part of the batch can be left in the pan and heating continued until it reaches 135°C (275°F). It will become very dark. It can be "reclaimed" by adding water and reboiling to 245°F. The final result will be quite different—a strong, possibly burnt flavor and dark color. Correcting an error this way is bad. A sample may also be taken when the caramel reaches 127°C (261°F)—this is a hard caramel.

Experiments 2, 3, 4. In these experiments the glucose syrup is

replaced by

1. Low DE glucose syrup
2. High DE glucose syrup
3. Invert sugar syrup

In each case, the caramel will be boiled to 118°C (245°F) but there will be appreciable differences in the final product. The caramel with low DE glucose will have increased viscosity (noted at pouring), be tougher finally, and be less sweet. The caramel with high DE glucose will be more fluid and sweeter.

Invert sugar gives greater fluidity, and a darker color in the finished product—it will also be noted that the caramel darkens appreciably on the cooling table. The flavor is changed too, with some loss of milkiness and a tendency toward bitterness.

Experiment 5. This is the manufacture of fudge. More will be said about this later. The basic caramel formulation is the same as Experiment 1, using 42 DE glucose but additionally 7 lb of fondant is added as follows:

The caramel is boiled to 118°C (245°F) as previously. Half the batch is discharged into another pan and cooled to 82°C (180°F) by immersing the pan in water. Half the fondant is added to the part batch at 118°C and the other half to that at 82°C. In each case, the fondant is well mixed into the caramel and then both are discharged on to a cooling table.

The caramel with the fondant added at the lower temperature will start to "set" fairly quickly while the other will remain soft for a long time. After 20 hr the first fudge will have quite a short texture while the other will still be soft, although showing some signs of "setting." When the fondant is added to hot caramel, the sugar crystals in the fondant are almost completely dissolved. In the cooled batch, they remain and encourage the crystallization of the sugar in the original caramel.

Caramel Texture

There are three consistencies of caramel—soft, medium, and hard—and they have boiling temperatures and moisture ranges approximately as follows:

	Boiling range	Moisture
Soft	118 to 120°C (245 to 248°F)	9 to 10 percent
Medium	121 to 124°C (250 to 255°F)	7 to 8 percent
Hard	128 to 131°C (262 to 267°F)	5 to 6 percent

The softer caramels are normally used for coating confectionery bars and for extrusion of layers.

The control of moisture content of caramel in open-pan cooking is difficult by hand thermometer because the mixer must be stopped and the delay in getting a constant reading not only gives wrong results but will cause overheating on the pan surface.

Some caramel cookers have built-in thermometers that are often so protected by masses of metal that they also give incorrect results.

The thermocouple or electric resistance thermometer is the best method of recording temperature. These devices are built with probe probes and may be attached to a portable lead for pan boiling. During continuous cooking the probe is inserted in the stream of current from the cooker and should operate a controller in the same way as that described under "Fondant Manufacture."

A skilled confectioner is able to determine hardness by taking a small sample from the boiling mixture and immediately immersing it in water. This method is of doubtful value.

The above figures are influenced by the proportion of milk solids and fat and the best way to assess texture is by means of a penetrometer.

The standard petroleum technology penetrometer used for bitumen may be adapted for caramel, and by the use of a cone or blunt needle consistent readings are obtained after maturing for 1 to 2 hr.

A modification of this apparatus uses a spring-loaded plunger operating a dial and corrections for ambient temperature can be applied. This instrument is used on the plant and figures are correlated with the temperature of boiling. A sample from the boil may be taken, cooled in water, and the reading taken after a minute or so.

There are many variations of caramel recipes using less milk reconstituted milks, different fats without butter, invert sugar instead of glucose. Caramels also may contain nuts, usually chopped coconut; chocolate; or raisins. Reclaimed syrup from scrap in the as caramel is one of the confections that can incorporate quantities of this without degrading the product.

It is not the purpose of this book to include large numbers of recipes and the reader is referred to other literature (see References) and one can make creative experiments once learning the general principles of manufacture. A series of articles by Lees (1976) give a great deal of information on "caramel formulations." Mention should

be made of substances that are added to modify the normal caramel texture. Chewing caramels are made by the inclusion of gelatin. The gelatin is included in a proportion of about 4 oz per 100 lb of caramel and is soaked and dissolved in water before adding at the end of the batch boil.

Corn starch or a modified starch such as Amaizo also produces a different texture and is added early in the boil in the form of a water slurry. It helps to prevent caramel from losing shape. A third modification is to add frappé and a typical recipe uses 6 lb of Hysoma type frappé to a 100-lb batch of caramel. Frappé must be incorporated without excessive mixing to obtain a low-density aerated product.

Much which has been said about caramels applies to the manufacture of toffee but toffee generally has a much lower moisture content and less milk and fat in the recipe.

Hard toffee is usually boiled to 149 to 152°C (300 to 305°F), which gives a moisture content of 2 to 3 percent.

Butterscotch is a particular type of toffee using butter as the only ingredient other than sugar and glucose. Some lemon flavor is usually added. A typical recipe and process is:

Granulated sugar	45.3 kg (100 lb)	Dissolve and boil to
(Glucose syrup	11.3 kg (25 lb)	143 to 145°C (290 to 293°F)
Water	18 kg (40 lb)	

Then stir in 8 lb butter (salted), and lemon oil (1 fl oz). The butter should disperse completely in the hot syrup. The partly cooled plastic butterscotch may be handled in the same way as toffee or caramel.

"English" Toffee, Nut Brittles

These are high boiled confections usually with much lower fat and milk contents than the caramels previously described. They are generally made from sugar only or with very low glucose content. They are particularly popular in the United States, where peanut brittle is sold in vast quantities. The nuts are, in effect, roasted as the syrup is cooked, the final temperature being 152 to 155°C (305 to 310°F). The following is an example of the process. This is a high-quality product.

Sugar (white granulated)	11.3 kg (25 lb)
Salted butter	9 kg (20 lb)

Added salt	71 g (2½ oz)
Lecithin	28.3 g (1 oz)
Chopped raw almonds	2.26 kg (5 lb)

Use, preferably, a stainless-steel pan. Melt the butter, add the water, sugar, salt, and lecithin, and mix very thoroughly using low heat until the temperature reaches 127°C (260°F). Then add the chopped almonds and continue heating until the temperature reaches 152°C (305°F). At this stage there is visible darkening between 152°C and 155°C (310°F) and the mixture becomes more fluid. Discharge quickly onto a cold table and spread rapidly into layers about 3/16 to 1/4 in. thick. This thickness is critical, otherwise the toffee becomes overcooked and develops a burnt flavor. A dividing frame may be pressed into the hot soft toffee to form bars. Variations with reduced butter and other nuts are possible. In such cases, a proportion of glucose syrup may be used with roasted or unroasted nuts. The degree of "roast" obtained by adding the nuts at different stages of the cooking process permits variation in flavor.

FUDGE (JERSEY OR ITALIAN CREME)

Experimental preparation of fudge has already been described. The origin of the candy called "fudge" was probably the accidental graining of caramel prepared with a high sugar content; in fact, if a high-sugar soft caramel is mixed vigorously while it is cooling, it is likely that crystallization will occur. This type of crystallization is uncontrolled, and gives a coarse grain, and, after a period, a spotty appearance. More reliable results are obtained by causing the crystallization by the addition of fondant. Nevertheless, the fudge made by the process of rapid mixing is the "home-made" product and has its devotees.

The flavor and texture of fudge are determined by the degree of boil of the original caramel base and the proportion of fondant. The proportion of sugar to glucose in the caramel recipe will also influence the crystallization of the fudge—the greater the sugar proportion, the quicker crystallization will occur.

The crystallization of fudge can also be obtained by the addition of finely powdered sugar to the partially cooled caramel base. This gives another texture, probably with more "tracure."

As with caramels, many other ingredients can be added to fudge to give very attractive candies. There is one important difference

between caramel and fudge—caramel is basically a fat emulsion in an amorphous syrup with the milk protein dispersed; fudge has a solid sugar crystal phase dispersed with the fat and milk protein in a syrup phase of a saturated solution of sugar and glucose. As a result, the fudge has a much higher water activity (ERH) and this must be borne in mind when packing or wrapping, or when it is used as a constituent of multiple confections.

Chocolate fudge is very popular in the United States. It is prepared by adding from 5 to 8 percent of cocoa liquor to the caramel batch before cooling. The addition of fondant follows during the cooling process.

Equipment for Caramel and Fudge Manufacture

The original equipment for the manufacture of caramel and toffee was a simple pan on a gas or coke fire. The process was as described

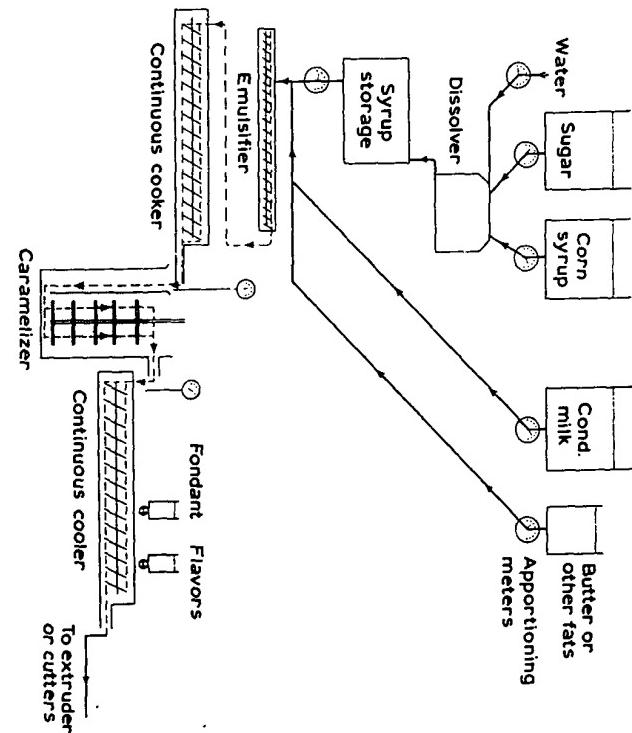


Fig. 19.15. Diagram of Continuous Caramel or Fudge Manufacture

in the previous experimental batches. Many confectioners say that gas or fire heating is the only way to get the right caramel flavor.

Fire heating was replaced by steam-jacketed pans. This was still a batch process and caramelization was still quite good. Some companies mechanized the batch system with a multiplicity of pans and pipelines, having been disillusioned with continuous processes.

However, study of the original batch process indicated the importance of the time factor in the boiling. The Maillard reaction—which takes place between the milk protein, reducing sugars, and water—is responsible for the final flavor, and the level of flavor depends on the

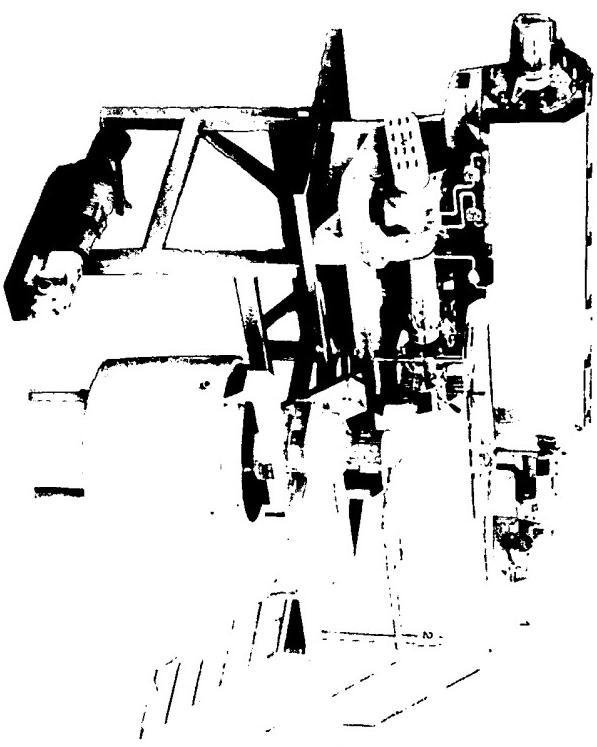


Fig. 19.16. Tourell Caramel Cooking Plant

2. Blender

The cooker is of tubular trough construction with five separate steam-jacketed sections plus a weir discharge. There is a special mixing scroll with variable-speed drive. The second section is used as a caramelize and for the mixing in of flavors, fat, etc. It is constructed to the same design as the cooker but with three sections of smaller diameter. Normal throughput is 1,000 lb/hr (450 kg) but machines are available up to 1,500 lb/hr.

Tourell-Gardner, Cornwall, England

time of heating, the proportion of reducing sugars, and the water present.

Continuous processes now include a caramelize which allows the continuously produced caramel to pass through a heater during a period of about 20 min at a temperature near the final boiling point of the caramel. This gives the correct caramelization.

The type of continuous process varies somewhat and a general principle is shown in Fig. 19.15. The trough cookers are of various types, for example, internally heated rotating "scrolls" in a heated trough or a mixer in a steam-heated trough. The base caramel mix is carried along the trough as it is cooked (Fig. 19.16). A similar arrangement can be used for cooling.

The trough cooler is particularly suitable for fudge manufacture. The fondant is extruded into the cooling trough. A different product is obtained by this method, and it is also important to realize that fudge pieces, cut from a slab prepared by the pan method described previously, give a material with a definite fracture, whereas the continuous process, particularly if extruded, gives a softer paste.

With the continuous process, it has been found advantageous to use a fondant with a higher sugar content—a ratio of 10 sugar to 1 glucose syrup instead of the usual 4:1 or 3:1.

There are also various designs of thin film and scraped surface heat exchangers (discussed under Hard Candy).

In considering the use of these cookers for caramel, the possibility of burnt films of milk product accumulating on the surfaces must be realized. If this happens, heat transfer is seriously reduced and dark particles may appear in the end product. The removal of these films is a difficult process and entails the filling of the cooker with strong alkali solution and thorough washing.

CROQUANTE (KROKANT), PRALINE (NUGAT), BRITLES

These products bear some relationship to toffees but usually there is no milk ingredient. The descriptions cause considerable confusion in different countries. Praline in English-speaking countries means a nut paste prepared by roasting nuts in high boiled sugar syrup followed by grinding. This is Nugat in Germany. Pralines in Germany refer to all chocolates with centers. Croquant (Krokant) usually means nut pieces roasted in high boiled syrup, also called Britles. (Note. International terms that apply to numerous confectionery

products, processes, and machinery are explained in *Silesia Confiserie Manual No. 3, Volume 1/11, German/English/French/Spanish.*)

Praline, Nugat

<i>Praline, Nugat</i>	
Almonds, blanched	4.53 kg (10 lb)
Hazelnuts	4.53 kg (10 lb)
Sugar	8.16 kg (18 lb)

The almonds and hazels are roasted at a high temperature—143 to 149°C (290 to 300°F). The sugar, dissolved in the minimum of water, is cooked to 157°C (315°F) and the roasted nuts added to the hot syrup and reheated to 157°C (315°F).

Alternatively, the nuts can be added to the syrup as soon as the sugar is dissolved and the mixture taken up to 157°C (315°F). The hot mixture is poured onto a water-cooled table, and when

cold, the hard mass is broken up, pulverized in a suitable mill, and then put through refiner rolls. The nut oil content is about 30 percent and when ground is an easily workable paste that can be used for flavoring and mixing with other ingredients.

Croquant (Krokant)

<i>Croquant (Krokant)</i>	
Chopped hazelnuts, almonds, or peanuts	2.26 kg (5 lb)

Sugar	4.53 kg (10 lb)
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The sugar is melted in a pan over a low fire and it is very important that all the sugar is contained in the melted mass. Slight residues on the side of the pan must be included and none of the sugar must be charred during the melting process.

When melting is complete, the chopped nuts are added and mixed in well. It is best to warm the nuts before adding to the syrup. The hot mixture is poured onto cooling tables, taking care to spread it out thinly to prevent overheating. The mixture passes through a plastic state, and in this condition can be formed into bars or pieces by pressing in a frame cutter or passing through drop rolls.

This process, using melted sugar, may also be applied to the manufacture of praline.

Traditionally, these products were made on a batch principle using special pans mounted over gas fires and provided with planetary mixers closely sweeping the sides of the pan. Recently, continuous cooking equipment has been developed that can be used for praline, croquant, and similar products (Figs. 19.17 and 19.18).

NOISETTE, CHOCOLATE PASTE, TRUFFLE PASTE

The nugat formulation may be modified by the addition of liquor, chocolate, or cocoa powder and vegetable fat.

Hazelnuts (or other nuts)	4.53 kg (10 lb)
Sugar	2.7 kg (6 lb)
Cocoa liquor	3.6 kg (8 lb)

The nuts are roasted and boiled in sugar syrup as with praline. After cooling and refining, the liquor or other ingredients are mixed in, with added flavors if necessary. It is then poured into trays to set. This formulation may also be termed a truffle base.

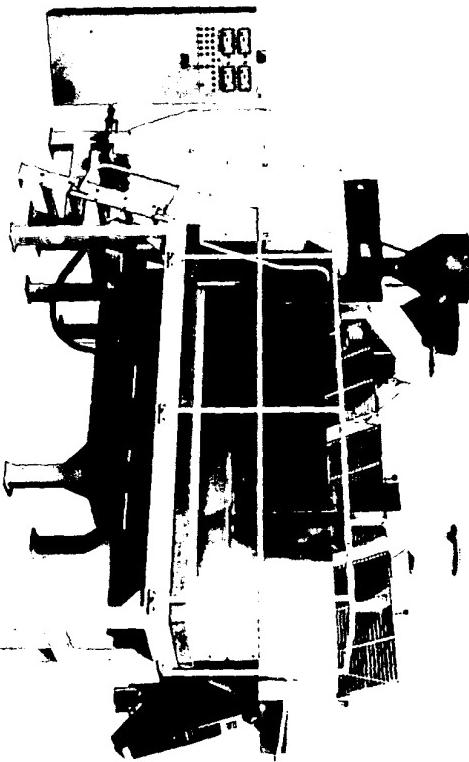


Fig. 19.17. Croquant Cooker

Continuous Automatic Cooking of:

—Praline, Krokant

—Melted and Caramelized Sugar

—Brittles

—Products Containing Fats—High Boiled Toffee, Butterscotch, etc.

Tourell-Gardner, Cornwall, England

Truffles

Of recent years, these have become a very popular confection, particularly in the United States. According to Richardson (1984), there are three main types—American, European, and Swiss.

The American truffle is usually a mixture of dark or milk chocolate with butter fat and hardened coconut oil, the texture being adjusted by variation of the quantity of added fats. The mixture must be subjected to a type of tempering before forming, which can be slabbing and cutting or, in certain circumstances, extrusion. This truffle, being virtually free of moisture, has a good shelf life.

The European truffle combines syrup with a chocolate base of similar ingredients (i.e., cocoa powder, milk powder, fats, sugars, glucose syrup, and invert). The final truffle is an oil-in-water emulsion with syrup phase concentration of 75 percent plus. Invertase may be added to assist in these respects. Assuming that these conditions are met and that the fat is well emulsified, shelf life is good.

The Swiss-type truffle is prepared from dairy cream, dark chocolate, and butter. The method of manufacture is to bring the cream and butter to a boil and then to add the melted chocolate, the proportions being approximately 60 percent chocolate, 10 percent butter, and 30 percent dairy cream. Sometimes egg yolks are added.

The ingredients are mixed in a whisking machine and then poured into trays to set. Aeration in the whisk helps to give some rigidity to the paste, which, after setting, is still very soft. It is frequently dusted with cocoa powder and cooled to aid handling, when it can be rolled into balls or piped into shapes. The formed pieces may be chocolate covered or rolled in vermicelli.

These truffles are very delectable but have a shelf life of only a few days. Freezing may extend this to a few weeks.

This formulation is suitable for the small candy shops that specialize in short-life confections such as chocolate-covered strawberries.

In Europe, particularly Germany, truffles invariably contain liqueurs such as brandy, Cointreau, and rum, and this considerably extends shelf life. Alcohol is a good preservative. A typical recipe using condensed milk instead of cream is as follows:

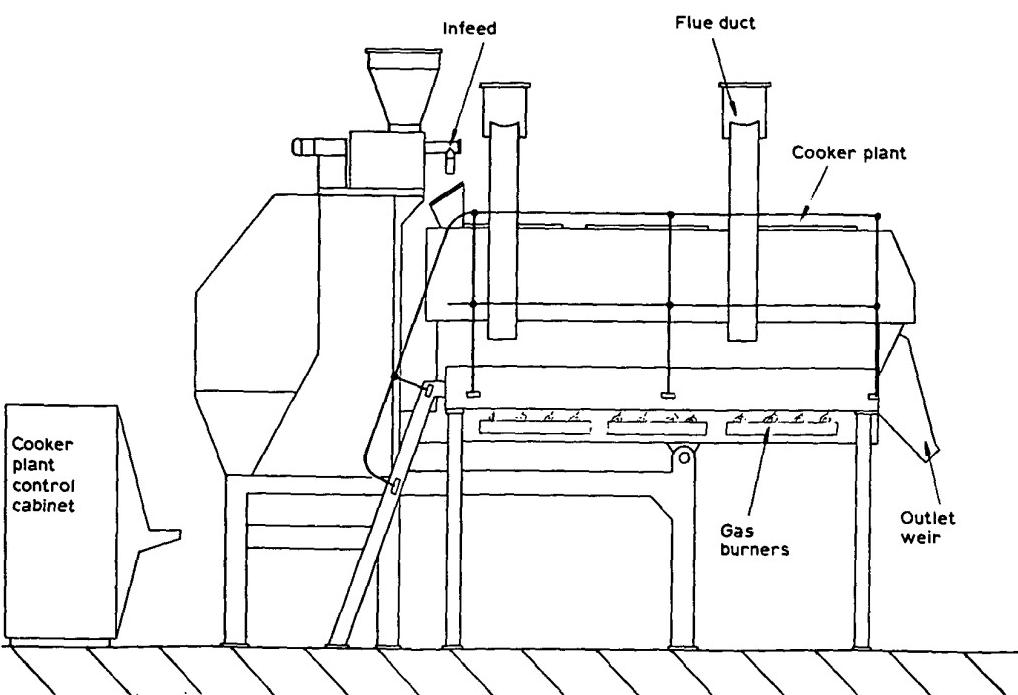


Fig. 19.18. Croquant Cooker

Tourell-Gardner, Cornwall, England

Dark or milk chocolate	500 g
Sweetened condensed milk	500 g

The chocolate is melted and the condensed milk warmed to about the same temperature. It is mixed in a planetary beating machine for 3 to 5 min and then, with slow mixing, 75 g Cointreau added. The mix is poured into a tray to set, and then formed or piped as noted previously. Truffle filling is also described under "Pulled Sugar."

BOILED SWEETS, HARD CANDY

Boiled sweets may be defined as highly concentrated solutions of sugar, glucose syrup, and sometimes invert sugar, with flavor added as required. The method of production is such that a glassy mass is formed in which the sugars are dissolved in less than 2 percent of moisture. The viscosity of the mass is so high that it is stable at normal temperatures provided that it is not allowed to pick up moisture. It is very hygroscopic.

The basic formulation is simple but great care is necessary in preparation, handling, and wrapping, or crystallization and moisture absorption will take place.

In hard candy sugar boiling, sugar alone cannot be used as it rapidly crystallizes while cooling, particularly if it is stirred. To prevent crystallization, the traditional sugar boiler used a process called "doctoring," and this meant the addition of a substance that inverted a proportion of the sugar. The substance that was used for many years was potassium hydrogen tartrate or cream of tartar, and this was added to the syrup at the beginning of the boilings. The quantity used was of the order of 1 oz to 25 lb (11.2 kg) of syrup and this produced sufficient invert sugar when the boiling was taken to 149 to 154°C (300 to 309°F).

Doctoring was an uncertain procedure and the quantity of invert sugar produced varied appreciably according to the time of boiling, purity of sugar, and hardness of the water used to dissolve the sugar. A more certain process is to incorporate a proportion of invert sugar or glucose syrup, and by so doing much more consistent results are obtained. The texture given by invert sugar addition is shorter and less chewy than glucose syrup and glucose imparts less sweetness.

There are some manufacturers of pulled boilings and Edinburgh rock who claim that the correct texture can only be obtained by the use of cream of tartar.

Process and Recipe for Sugar Boilings

The original sugar boiler used gas- or coke-fired boiling pans. These were superseded by high-pressure steam pans and now by continuous and vacuum cookers.

Much can be learned by the student or a newcomer to the industry by making some boilings by the pan method and a typical procedure is as follows:

Sugar (high-grade granulated)	14 kg (6.35 lb)	proportions
Glucose syrup (42 DE)	3 kg (1.16 lb)	may vary
Water	5 kg (2.27 lb)	

Dissolve the sugar in the water and bring to the boil—then add the glucose and bring to the boil again. An essential procedure is to see that any traces of sugar crystals around the pan above the level of the boiling syrup are washed down and dissolved completely. The old sugar boiler used a wet brush for this but a steam jet will also prove satisfactory. Traces of residual solid sugar will cause grain to develop and this will be very detrimental to shelf life of a finished product. When the boiling has reached 143 to 146°C (290 to 295°F), a solution of color may be added and this must also be free from solid particles. Boiling is continued to 150°C (302°F) and the syrup is then poured out onto an oiled table and allowed to cool until it is plastic but still soft and mobile. The edges of the mass are folded inward and a depression made in the center of the mass. Into this are placed finely powdered citric acid (monohydrate) 0.5 to 1.0 percent and the flavoring essence and the folding and kneading are continued until the ingredients are dispersed throughout the plastic mass. When cool enough, the batch is cut into sections and fed into "drop rolls," which press the plastic sugar into shapes. On a large scale, the plastic sugar is supplied to a batch roller that forms it into a "rope," which may be pressed into shapes in a continuous former.

LARGE-SCALE PRODUCTION

Syrup Dissolving and Cooking

The sugar, glucose, invert (and sometimes "scrap" syrup) may be metered into continuous dissolvers. These provide a supply of syrup of constant composition to the cookers (Fig. 19.19).

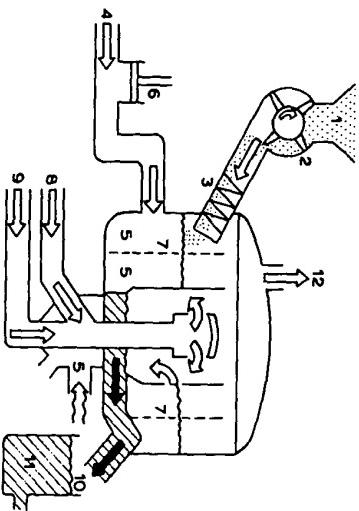


Fig. 19.19. Continuous Dissolver
 1. Granulated Sugar Feed
 2. Metering Wheel
 3. Worm
 4. Water Feed
 5. Steam
 6. Water Pump
 7. Mixture of Sugar and Water
 8. Glucose Feed
 9. Feed of Other Ingredients
 10. Preboiled Solution of Sugar and Glucose
 11. Intermediate Container
 12. Boiling-Vapor Discharge

Hämac-Höller, Viersen, West Germany

The cookers may be thin-film batch or vacuum. The Microfilm cooker (Fig. 19.26) has already been mentioned in the production of fondant. It operates with a steam pressure of 120 to 150 lb./psi. The principle of this cooker is for a thin film of syrup to be spread mechanically over the inner surface of a cylinder heated by the high-pressure steam. The rapid heat exchange to the thin film evaporates the water very quickly from the syrup and the cooked syrup is then discharged onto a water-cooled rotating table with an aperture in the center that removes the partly cooled syrup. This cooled mass is conveyed on steel belts and through automatic kneaders where the acid, flavors, and colors are continuously incorporated. The flavored plastic mass is then fed to forming machinery as follows:

Batch former. This consists of ribbed conical rollers that revolve and oscillate. The plastic sugar mass is placed in the top end of the machine where the rollers are widest. By means of the movement of these rollers, the mass is reduced to a rope 2 to 3 cm (0.8 to 1.2 in.) in diameter (Fig. 19.20).

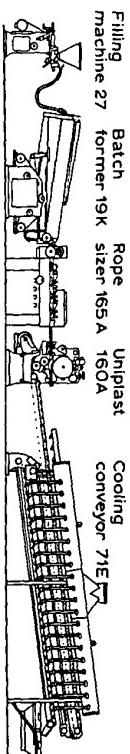


Fig. 19.20. Hard Candy Production Line

Hämac-Höller, Viersen, West Germany

Rope sizer. This takes the rope from the former. The sizer consists of four pairs of channeled "wheels" through which the rope must pass, thereby making the rope of precise diameter. In both the former and rope sizer, it is obvious that the temperature and plasticity of the sugar mass must be correct and even throughout. The forming rollers may be of variable dimensions according to the size of candy required.

Sweet forming die head. The rope, still in a plastic state, is fed into this machine and is subjected to a series of die plungers that press the rope into individual pieces. The pattern of these pieces is determined by the impressions on the surface of the die (Fig. 19.21).

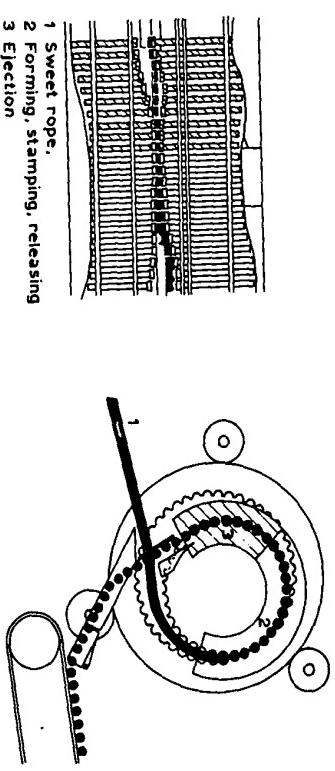


Fig. 19.21. "Uniplast" Sweet Former
Method of operation: The sugar rope arriving from the batch former and rope sizer is led into a pair of sizing rollers and then runs on into a rotating die head fitted with plungers and guiding cams for the stamping and forming of the individual candies. The formed candies are then delivered onto the narrow top belt of the 71E cooler, which is driven by the

Hämac-Höller, Viersen, West Germany

Cooling conveyor/wrapping machine. The candies from the die head are then delivered to cooling conveyors to prevent deformation. These are of metal netting, which, with air circulation, provide the necessary dissipation of heat (Fig. 19.20).

Center filling. It is possible to deliver a filling to the center of the rope by means of a hopper and feed pipe. The filling may be fatty pastes or concentrated fruit preserves, and these are introduced into the rope while forming in the batch rollers (see later "Soft-Center Bonbons").

Packaging. There are numerous types of packaging machines but it is always desirable to wrap the pieces while they are still slightly warm and preferably the packing room should be air conditioned to a relative humidity of 45 percent. This prevents sticky surfaces and subsequent "graining."

Vacuum Cooking

There are several advantages of cooking the syrup for boiled sweets under vacuum:

- The color of the syrup is better; fire cooking causes some browning.
- The temperature of boiling is lower, which reduces the inversion of the sucrose ingredient. This helps to retain a light color in the syrup.
- there is a saving in evaporation costs; cooking time is shorter.

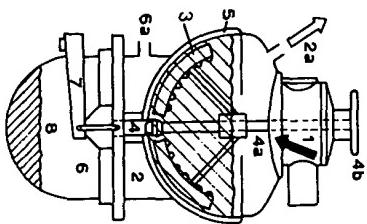


Fig. 19.22. Vacuum Boiling Pan
1. Filling (Water, Sugar, Glucose, and Possibly Milk and Fat)
2. Batch Cooker
2a. Vapor Exhaust
3. Mixer
4. Valve
4a. Valve rod
4b. Valve Operating Wheel
5. Steam Heating
6. Vacuum Chamber
6a. Vacuum Connection
7. Swivel Device
8. Delivery Pan with Ready Boiled Sugar Mass

Hämac-Höller, Viersen, West Germany

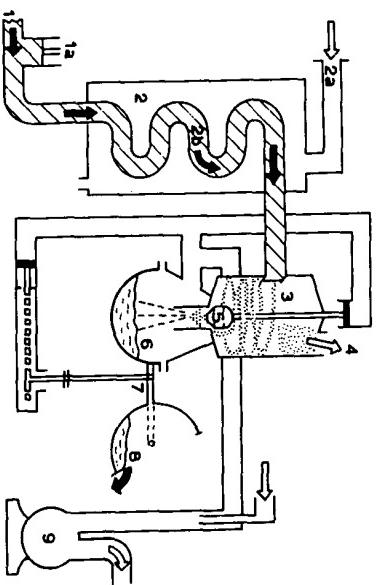


Fig. 19.23. Continuous Vacuum Boiling System
1. Precooked Sugar-Glucose Solution
1a. Feed Pump
2. Steam Chamber
2a. Steam Supply
2b. Cooking Coil
3. Vapor Space
4. Extraction of Vapors
5. Valve
6. Vacuum Chamber
7. Pan-Swiveling Device
8. Discharge Pan
9. Vacuum Pump

Hämac-Höller, Viersen, West Germany

There are batch, semicontinuous, and continuous vacuum cookers. Brief descriptions and diagrams are given in Figs. 19.22 and 19.23).

Normally, in vacuum cooking the proportion of glucose syrup is higher and in a batch cooker there is a syrup cooking pan mounted above a vacuum pan. After cooking the syrup to a given temperature in the upper pan, it is drawn by the vacuum into the lower pan. A valve, which can be controlled, delivers the syrup at a standard rate. Acid, flavor, and color are added to the syrup in the pan and stirred. This is followed by discharge to a cooling table, and when in the correct plastic condition, it is formed into a rope and then pressed into shaped pieces as described previously.

An example of a formulation and cooking conditions is as follows:

Glucose syrup (42 DE)	15 kg (33 lb)
Sugar (high-grade granulated)	15 kg (33 lb)
Water	5 kg (11 lb)

Cook sugar and water to 110°C (230°F). Add glucose and cook to

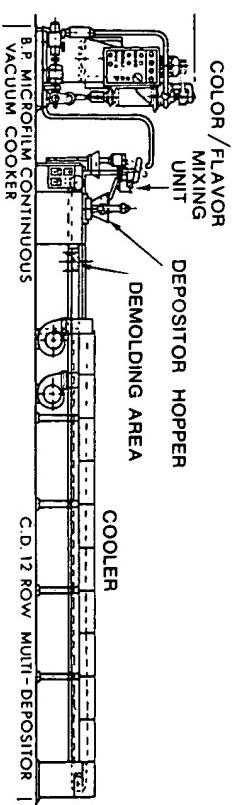
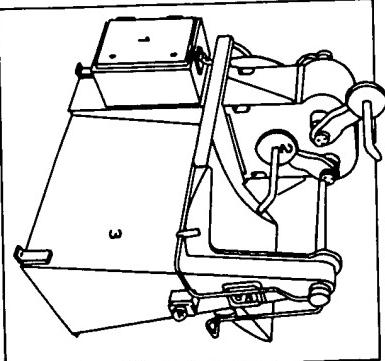


Fig. 19.24. Continuous Candy Molding Plant

Baker Perkins, Peterborough, England

Fig. 19.25. Sugar Pulling Machine
1. Control Box
2. Pulling Arms
3. Frame
Hannac-Holler, Viersen, West Germany



138°C (280°F). Vacuum is drawn in the lower pan at 620 mm (24.5 in.). The discharge time of the syrup to the lower pan is 3 min.

Another method of continuous production is used for making clear fruit drops. The high boiled syrup is deposited into impressions in metal molds that are coated internally with a "release agent." The molds are cooled and the units are then easily removed.

This process necessitates the addition of flavoring, color, and acid to the high boiled syrup and special types of flavors are required to reduce loss of volatile constituents. Buffered lactic or malic acids are used in the process in place of citric acid (Fig. 19.24).

PULLED SUGAR, SOFT-CENTER BONBONS, AERATED BOILINGS, FOURRÉS

The "pulling" of sugar is another example of the sugar boiler's craft. The process consists of cooling the boiled sugar mass until it reaches the plastic state and then stretching it, folding over, and stretching again until it becomes translucent and develops a sheen. Continued pulling increases the opacity and eventually, if the sugar/glucose proportions are correct, the mass will "grain off" and become quite short in texture. Air is also incorporated during this process. The graining may be accelerated by storage under warm humid conditions at about 38°C (100°F).

This method is frequently used for after-dinner mints, one of the few formulations that uses cream of tartar (see later).

The sugar boilers who carried out this process by hand used a large

hook about 6 in. long and $\frac{3}{4}$ in. in section fixed about 6 ft high on the wall adjacent to the cooling table. When the mass of boiled sugar was sufficiently plastic, it was slung on to the hook stretched downward, and then over the hook again, and this process was repeated until the desired condition was obtained. Gloves were necessary to handle the hot mass repeatedly and the final condition of the product depended entirely on the sugar boiler's judgment.

This process has been mechanized by the use of oscillating cranks that fold and pull plastic sugar batches of 56 lb. This operation can be timed precisely and a more constant product is obtained (Fig. 19.25). Pulled sugar can be used as a casing for centers such as soft caramel, jam paste, chocolate paste, truffle, or sherbet, and these are often called bonbons.

The following are typical processes and recipes for this class of confectionery but many others are possible, depending on the skill and ingenuity of the experimental confectioner.

<i>Edinburgh Rock</i>	11.3 kg (25 lb)
Sugar	3.6 kg (8 lb)
Glucose syrup	3.85 kg (8½ lb)
Water	

Dissolve the sugar and glucose in the water and boil to 138 to 139°C (280 to 282°F). Pour onto the cooling table, fold in from the

edges, and when plastic knead in

Citric acid power	113 g (4 oz)
Lemon flavor	
Yellow color solution	as required

When well distributed, place the mass on the pulling machine and keep running until the batch has developed a spongy texture. The mass is put through formers to obtain a diameter of 2 to 3 cm (1 in.) and then cut into bars. On cooling, the bars will grain and become quite short.

This class of product contains air in finely divided form and is in intimate contact with the flavor ingredient. This fact is also mentioned in the section on marshmallows and certain flavors, particularly essential oils, are very susceptible to oxidative deterioration under these conditions.

Flavors resistant to oxidation must be used; reputable flavor manufacturers can give advice on the most suitable type and synthetic citrus oils are usually better than the natural oils for this kind of confectionery. This is very important—there are many instances of rock being sold in an unpalatable condition because of this alone.

Mintoe-Type Hard Candy

This is a very popular class of sweet and aeration is obtained by the inclusion of frappé.

Frappé

Egg albumen (or substitute)	142 g (5 oz)
Water	284 g (10 oz)
Soak with occasional stirring until dissolved.	
Mix, and then add	
Glucose syrup	1.81 kg (4 lb)
Whip to a stiff foam.	

Syrup	9 kg (20 lb)
Sugar	6.8 kg (15 lb)
Glucose syrup	3.1 kg (7 lb)
Water	Dissolve and boil to 138 to 139°C (280 to 282°F)

Add the frappé and beat into the syrup, allow to cool to about 121°C (250°F). Then quickly mix in the following.

Butter	0.90 kg (2 lb)
Peppermint oil	14 g ($\frac{1}{2}$ oz)

Note: Peppermint oil is a very volatile flavor and some will rapidly evaporate off the surface of a high boiling. This will not only reduce the strength of the flavor but will change its character as some fractions of the oil will distill off more readily. An emulsion of the flavor can be prepared, but encapsulated flavors are also available.

Soft-Center Bonbons

These confections are made by feeding the liquid center composition from a hopper through a flexible tube into the plastic boiled sugar mass. This is done in the batch roller and the soft mixture becomes a core in a high boiled casing and this is carried away to the forming rollers that press the plastic rope into individual pieces with a soft center. (See previous descriptions and diagrams.)

This is also a skilled procedure, as the casing must be handled as hot as possible and the center should be about the same temperature. To obtain a satinlike sheen, the boiled sugar casing is pulled for a short period only and is generally colored and flavored in a minor way. The soft center must contribute most of the flavor.

Casing recipe	
Sugar	11.3 kg (25 lb)
Glucose syrup	3.6 kg (8 lb)
Water	3.85 kg (8½ lb)

Dissolve the sugar and glucose in the water and boil to 146°C (295°F). The boiled sugar is poured onto the table and flavored and colored as previously described, and, if desired, pulled to give the required appearance.

Center Recipes

Jam Center	
Raspberry jam	11.3 kg (25 lb)
Glucose syrup	5.5 kg (12 lb)
Water	0.90 kg (2 lb)
Citric acid	21.2 g ($\frac{3}{4}$ oz) dissolved in 28 g (1 oz) water
	Heat the jam, glucose and water and then boil to 117°C (242°F).

Cool slightly, then add the citric acid solution, flavor and color as desired. This mixture is best prepared freshly before use and kept warm.

<i>Truffle center</i>	
Fondant creme	11.3 kg (25 lb)
Cocoa liquor	1.36 kg (3 lb)
Sweetened condensed milk (full cream)	2.72 kg (6 lb)
Vanillin, color as required	

Melt the fondant at 60 to 63°C (140 to 145°F) and stir in the liquor. Heat the condensed milk to 93°C (200°F) with careful stirring for 15 min and then add to the fondant and stir in well.

Nougat, soft toffee, and various paste centers can be made. It is well to avoid "cold process" centers in which mixtures are made without heating to a temperature that will destroy microorganisms and lipolytic activity. Alternatively, ingredients may be sterilized by heating before use. Milk products, some preserved fruits, and ground nuts may cause trouble, and it is always necessary to maintain a minimum syrup phase concentration of 75 percent in the centers.

After-Dinner Mints

Sugar	15 kg (33 lb)
Cream of tartar	45 g (1.6 oz)
Water	6 kg (13.2 lb)

Boil to 135°C (275°F). Pour onto table to cool, then fold into center.

Icing sugar	750 g (26.4 oz)
Peppermint oil	7 ml (0.25 oz)

Pull until spongy consistency is obtained, then put through formers and store the pieces in warm, humid conditions until they are short in texture.

These mints can be made without the icing sugar, the graining taking place during pulling and subsequent storage. Graining is slower and texture of the finished mints is different.

True Bonbons, Fourrés

The original bonbon consisted of a center of nut paste, marzipan, preserved fruit, or truffle dipped in fondant creme. Fondant creme is melted at 60 to 63°C (140 to 145°F) and

transferred to shallow, hot-water-jacketed pans. These are usually fitted into tables so that the rim is level with the table surface and the water circulation is thermostatically controlled. The centers are coated by the method of fork dipping as used for hand covering with chocolate and for this purpose a two or three-pronged wire fork is used. The center, balanced on this, is immersed in the liquid fondant and removed with the fondant coating and then inverted on to a waxed paper layer in a tray. This is a hand process, highly skilled if uniformity is to be obtained, and expensive.

Fondant recipes that have low glucose syrup content are often used for this process in order to give quick setting of the fondant. These should not be used if good keeping qualities are required. Some confectioners advise the inclusion of 0.05 percent of acetic acid as a preservative but it is possible to use the conventional recipe fondant if sufficient time for drying is allowed after coating.

These bonbons can be crystallized or covered with pastel or white chocolate coating.

Mechanical methods have been devised for fondant coating, but one of the problems is constant evaporation of moisture from the fondant itself, giving gradually increasing thickness to the fondant layer. Syrup of 75 percent concentration and the same sugar/glucose ratio as the fondant may be mixed in judiciously to decrease viscosity but water must never be used.

SPECIAL PROPERTIES OF BOILED SUGAR CONFECTION

While boiled sweets are relatively simple in formulation, they are subject to physical changes that greatly affect their shelf life. Chemical changes, inversion, and "caramelization," also have a marked effect on their properties.

The following scientific data should provide some understanding of the problems associated with high boilings.

Microstructure

High boiled sugar has been likened to glass, being in a metastable state between the completely amorphous and crystalline state.

Maintenance of a condition close to the amorphous state is a result of the very high viscosity of the boiled sugar at ambient temperatures. A change towards the crystalline state is brought about

through reduction of viscosity by either raising the temperature or increasing the moisture content. Hence, warm storage or damp conditions encourage the graining of high boilings and caramels.

A publication by Andersen (1968) describes many interesting features of hard boilings. The following are the main observations.

Strain Strain striae observed optically in freshly deposited high boilings disappear fairly quickly, showing that the sugar is still in a mobile condition although of very high viscosity. Similar striae in glass are practically permanent.

Air Occlusions Vacuum cooking, kneading, and pulling produce air bubbles of different shapes and sizes and these affect the smoothness of the product.

Flavor Substances These are frequently very badly dispersed and appear as large droplets unevenly distributed throughout the mass. Citric acid particularly is mentioned and unmelted crystals have been found throughout the mass of hard candy. The melting point of citric acid crystals is given as 126°C (259°F) or anhydrous 153°C (307°F) so that good dispersion would be expected only with the crystalline acid if it is incorporated in the very hot or liquid melt. Acid particles give an unsatisfactory flavor sensation.

Water Activity (ERH)

There is a great difference between the water activity of boiled sugar "glass" and the same composition when crystallized (0.25 compared with 0.75).

The noncrystalline sugar is very hygroscopic and will readily pick up surface moisture. If this is allowed to happen, a relatively dilute syrup is formed on the surface. This will crystallize and the dilute syrup generated will set up a type of chain reaction, and eventually the whole sweet will crystallize. Hence, it is important to wrap the candies immediately after forming.

Composition

Most boiled sweets are now made with sugar- and glucose syrup. Invert sugar is rarely used, except in countries where sugar is grown and glucose is not readily available.

The ratio of sugar to glucose varies according to the method of boiling—open pan, thin film, or vacuum. However, it is also related to the type of glucose used (see "Glucose Syrup"), for example, the low conversion glucoses are very viscous, less hygroscopic, and less sweet. In any composition, the sugar ingredient is subject to breakdown into the two monosaccharides, dextrose and fructose. The fructose causes the candy to be more hygroscopic and liable to become sticky when exposed to the air.

Vacuum cooking reduces inversion because temperatures are lower and boiling time shorter. The inclusion of "acid scrap" will bring about considerable inversion. Such scrap should be dissolved, neutralized, and decolorized before use (see "Reclaiming").

Color

The longer the boiling and higher the temperature, the more the color changes toward yellow or light brown. Fruit drops, clear mints, and similar products need to be free from this defect.

Faults

These are summarized, with possible causes, as follows:

The candies have become sticky. They have picked up moisture from the air and causes are

1. Too much "invert" content (see above).
2. Relative humidity of forming and packing room too high. Packing room should be 45 percent relative humidity or below. Candy should be wrapped warm at about 32°C (90°F).
3. Unsuitable packaging material—moisture vapor transfer of candy wrap and bag wrap too high.
4. Humid conditions at point of sale [also related to (3)]

The candies have "grained"

1. Sugar/glucose ratio too high.
2. Moisture content too high.
3. Addition of solid "scrap."
4. Humid storage.
5. Warm storage.

With reference to (5), it should be understood that warm conditions have the effect of softening the hard amorphous candy. This will

make the very concentrated syrup more mobile and liable to crystallize.

AERATED CONFECTIONERY—PROBLEMS AND CONTROL

The incorporation of air (or other gases) in foodstuffs has been practiced for many centuries. The leavening of dough by fermentation is an example of forming a spongy texture from a dense mixture. There are various methods of aeration that increase bulk for a given weight, thus improving texture, possibly digestibility, and generally appearance of better value because of the increased size of the product.

Mechanical

1. Air or an inert gas such as nitrogen may be introduced into a syrup or fat by mechanical beating under normal or increased pressure. To prevent premature collapse of the foam, stabilizers are usually added. These may be gelatin, egg albumen, hydrolyzed milk protein, or edible gums. Marshmallows and nougat are typical examples of confections made by this method.
2. Air or gas may be dissolved under pressure in a syrup, fat mixture, or chocolate, and when this mixture is allowed to exude from a nozzle in the pressure vessel, it will expand by reason of the gas coming out of solution in the form of small bubbles.

Aerated chocolate can be made by this method. Carbon dioxide will dissolve quite readily in warm liquid cocoa butter under pressure and liquid chocolate can be subjected to this treatment. When it is extruded through nozzles from the pressure mixer, the gas comes out of solution and a viscous chocolate foam is formed. This can be deposited into molds or formed into slabs and solidified by cooling.

3. Pulling and kneading—are used for hard boilings when in the warm plastic condition and air is entrained during the process of folding and pulling. Satin hard boilings and Edinburgh rock are examples of this type of confectionery.
 4. In extrusion, plastic high boiled sugar is forced through a plate with multiple star-shaped perforations, the threads joining up loosely after extrusion to form channeled strips.
- There are several machines that extrude high boiled sugar

and the result is a type of honeycomb that gives a crisp texture. The voids can be filled with a soft paste such as peanut butter.

5. Flaking off rollers and compacting the flakes to form a channeled bar are used for chocolate, fat pastes, and some boiled sugar products. It gives a bar with structure somewhat similar to (4) but less regular. (See "Chocolate Flake.")

Some confections that are already aerated in a minor way by one of the previous methods can be considerably expanded by treatment in a vacuum vessel or oven. If heat is applied with the vacuum, cooling is required before the vacuum is released or the aeration will collapse. If drying occurs with the application of vacuum, cooling may be unnecessary.

Chocolate may be aerated by vacuum treatment. The liquid chocolate is first tempered; it is then rapidly beaten (without destruction of the temper). This introduces small air bubbles throughout the mass, and when subjected to vacuum, these will expand. The chocolate is then allowed to set, which will happen fairly rapidly under moderate cooling conditions and if the chocolate is well tempered. Setting must take place under vacuum.

Pulled boiled sugar will expand a great deal if the warm plastic product is subjected to vacuum but the expanded article must be cooled quickly to prevent collapse.

Under these methods, a reference should be made to pressure gun puffing, which is used for cereals and some other products. The cereal grains containing their natural water content are heated under pressure in a special cylinder to a temperature well above the boiling point of water. The cylinder lid is suddenly released and the moisture in the cereal cells is instantaneously transformed to steam and the cellular volume is greatly increased.

Chemical Methods—Surface Activity—Stability of Foams

Certain chemical substances decompose under heat; sodium bicarbonate is the most important example, yielding carbon dioxide. Others react without heat but in the presence of moisture; sodium bicarbonate plus citric or tartaric acid are examples. It is generally necessary to control the degree of aeration and bubble size by means of stabilizers.

The following examples explain the problems involved:

In the days of the individual candy makers using batch processes,

aeration could be controlled, as thought fit, by adjustment of the quantity of aerating agent or modification of the process.

With modern continuous processes, it is necessary to use a precise recipe and to understand the properties of the ingredients that are responsible for giving a standard volume to the aerated product with consistent gas bubble size.

The surface activity of ingredients of any particular confectionery product must be considered if control of the foam responsible for aeration is to be obtained.

A simple example is the expansion of a high boiled syrup by the addition of sodium bicarbonate, which decomposes by heat into sodium carbonate, steam, and carbon dioxide ($2\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2$).

A similar reaction occurs if an organic acid (A) such as citric or tartaric is added ($\text{HA} + \text{NaHCO}_3 \rightarrow \text{NaA} + \text{H}_2\text{O} + \text{CO}_2$). In each case, the carbon dioxide is evolved in the form of small bubbles, which are dependent on the particle size of the bicarbonate. The strength of these bubbles and their ability to coalesce into larger bubbles are dependent on surface activity. The structure of the resultant honeycomb may vary greatly because of this factor alone.

Hard candy foam, known in the trade as "cinder taffy," "honeycomb," or "crunch," has been made for many years and sold in lumps in fair grounds. To make it in bar form with consistent density and aeration needed study of the surface properties of the ingredients.

In the development of a continuous process for the manufacture of this bar, the properties that controlled the bubble size and stability of the aeration were determined. Two factors were shown to be responsible.

1. The particle size distribution of the sodium bicarbonate.
2. The foam-forming properties of the sugar and glucose syrup ingredients.

The particle size distribution of the bicarbonate was determined, first, by microscope and elutriation measurements in coordination with grinding experiments on a micropulverizer. These measurements were related to performance in experimental and factory production using the same syrup. Ultimately a quick sediment test was developed that proved equally satisfactory in giving an empirical judgement of size distribution.

When investigating the factors that determined whether the

bubbles coalesced, it was found that certain "surface active" substances in the sugar and glucose could give variations in density and bubble size, resulting in considerable variation in the candy product.

The quantities of these substances were so small that they were not readily detected by quantitative analytical methods and physical tests were therefore applied. Surface tension measurements were tried but the practical difficulties were so great, particularly if they had to be applied to routine testing, that they were abandoned in favor of foaming tests.

Two methods were used to investigate foam-forming tendencies in the sugar ingredients. The first consisted of a "foaming stone" used for oil testing, and this was connected to an air supply and meter that delivered air at a constant rate into a syrup held in a graduated cylinder.

This served admirably to show up gross variations in sugar and glucose ingredients, and in the early days of research variations were very great, particularly in glucose syrup and some beet sugars. It showed that foam values obtained by this method gave a close correlation with the nature of the aeration in the aerated high boiling.

As development of the continuous process proceeded, greater accuracy was needed and an improved method for foam value was devised. This method is similar to that proposed by Bikerman and modified later by Clark and Ross (1940)—it is the determination of the "dynamic foam" value. Details of this method are given in the Appendix.

At the time of the original investigations, sugar and glucose manufacturers had little knowledge of the foaming properties of their products. It was possible to show that there were significant differences between some high-grade sugars prepared from cane or beet raws. Beet sugars had high foam values whereas cane sugars had low values and in some cases showed no foaming tendencies. In low grade or badly refined sugars, these differences were very marked, and as the refining improved, the foam values of sugars of cane or beet origin became much closer.

Beet sugars may contain minute amounts of protein matter, mucilage, saponins, and similar foam-producing substances. Cane sugar, on the other hand, may contain small amounts of cane wax, which has some antifoam properties. High ash contents in sugar also contributed to foam formation.

In the examination of glucose syrup it was found that significant amounts of protein residues may be present that produce very

marked foaming but no direct connection between nitrogen content and foam values was found.

Some of the glucose syrup manufacturers recognized that these residues were liable to cause foaming, and to avoid trouble in the evaporators, antifoam substances were sometimes added. This had the disastrous effect of causing very coarse aeration in the aerated product, and in some cases almost complete coalescence of the gas bubbles. At the same time, the density increased greatly.

At the present time, most manufacturers of sugar and glucose syrup are well aware of these problems and the degree of refining is to a very high standard. However, some sugars and glucose syrups of foreign origin still exhibit the difficulties mentioned.

These special properties of sugar and glucose syrup are not only significant in aerated boilings but may be responsible for troubles in clear boilings where foaming may cause difficulty at the boiling stage or produces unsightly bubbles in the finished product.

Stability of Foams

The stability of a foam, whether in hard boilings, marshmallows, nougats, or other confections, is important if constant density and good keeping properties are to be achieved.

Destruction of foam structure is readily brought about by the presence of fatty material, fatty acids, essential oils, and various other flavors. In an aerated high boiled sugar product without a stabilizer, very small amounts of fat are damaging. Even when stabilizers such as egg albumen or gelatin are present, fat can cause considerable variation in low-density aerated confections.

In experiments made to assess the effect of stabilizers in aerated boiled sugar, the additions of gelatin, albumen, gums, and hydrolyzed milk protein were investigated. The presence of 10 parts per million of gelatin was shown to produce a very fine aeration but addition of these substances to the syrups to try to control foam led to difficulties in the syrup cookers. Very small additions of protein material to the cooked syrup or with the aerating chemical gave better control. These same products, however, showed a completely changed aeration structure if a fat or fatty acid was added to the extent of 100 to 500 parts per million, and in some cases most of the aeration was lost completely. The stability of the foam in a confection is also affected by the extent of mixing. Overmixing has the effect of producing a "sponge" where some of the bubbles are connected but have not coalesced into larger bubbles.

Foam collapse, whether due to a fatty oil or overmixing, will occur in high boiled products only when the magma is hot, but with higher moisture confections such as marshmallows the collapse is progressive over a long period.

There are several high boiled confections on the market that have had considerable additions of gelatin, albumen, or milk protein. They are generally not crisp, and have a higher moisture content (5 to 7 percent) and a very close aeration.

The crisp aerated high boilings without stabilizer addition have a coarser aeration and lower moisture content (3 to 4.5 percent).

When it is necessary to add a fat or essential oil to an aerated product, it is possible to reduce its antifoam properties by making an emulsion in syrup but the syrup, not the fat, must be the continuous phase.

Shelf Life of Aerated Confectionery

Reference to shelf life is made elsewhere in the description of particular types of confectionery but some general observations are given here as this is a very important aspect of these lines.

Oxidative Rancidity

Because of the intimate contact of air with the other ingredients in an aerated product, oxygen may cause deterioration of flavoring materials and fats. The stability of such ingredients should be checked by accelerated oxygen absorption tests. Some essential oils are very badly affected in a product such as marshmallows and some natural fruit flavors lose their strength.

Fats in nougats and light texture fudges may develop rancidity but fat deterioration is more likely to be due to lipolytic activity.

Microbiological Spoilage

Aerating agents, particularly egg albumen, are heat sensitive and there is a tendency to keep processing temperatures as low as possible to preserve the properties of the whip; marshmallow is an example. Pasteurization temperatures in the region of 74°C (165°F) for 15 to 20 min will destroy most organisms liable to cause spoilage if the heating is carried out in water solutions or dilute syrups, but with more concentrated substrates these organisms are resistant to higher temperatures.

The maintenance of a syrup phase concentration of 75 percent minimum will avoid most trouble but occasionally osmophilic yeasts may cause fermentation, and liquefying bacteria can produce local breakdown of the foam.

A more serious problem of spoilage arises from fat-splitting enzymes that are associated with the microorganisms. Esterases and lipases are very resistant to destruction by heat in low moisture substrates. Temperatures of 93°C (200°F) for 20 min will destroy these enzymes in 75 percent concentration syrup but in dry powders such as cocoa, temperatures up to 115°C (235°F) have been found necessary.

Fat-splitting enzymes are responsible for "soapy rancidity" in nougats and fudges, especially where lauric glyceride fats are used.

Ingredients and processes should be checked at all stages of manufacture, particularly in continuous production, where process temperatures may be of short duration.

Aeration, by reason of the very fine division of air cells in a confection, will promote the deterioration of many ingredients—flavors, fats, milk solids, nuts.

The phenomenon of "microclimates" should also be mentioned. This concerns the minute atmosphere within a bubble that may, locally, have a very high relative humidity. In such circumstances, a localized deterioration may occur. This condition often arises due to poor mixing or emulsification.

Cold Cracking

This is an interesting phenomenon of light, aerated, low-moisture products when covered with chocolate. Chocolate-covered sugar "honeycomb" or light cookies will, if subjected to temperatures below 40°F, develop cracks in the covering, and if temperatures reach 20°F or below, they may shatter completely. Milk chocolate shows this defect much more than dark chocolate.

This cracking will accelerate moisture gain in the center. With aerated boiled sugar, this will cause collapse of the center to, in the worst circumstances, a syrup. With wafer cookies expansion occurs and the chocolate will split off. The wafers become tough. The reasons for this cold cracking have been investigated and they may be attributed to the following.

1. *Mechanical strength of the centers.* A light crisp "honeycomb" or cookie will break up under stress. Soft centers are able to adjust

their shape slightly if subjected to outside forces. Similarly, dense solid centers will not break or change shape under ordinary stresses.

2. Composition of the chocolate covering.

Milk-chocolate-covered centers are most susceptible to damage under cold conditions. From dilatation measurements the fat portion of many milk chocolates under ambient conditions contains about 20 percent of liquid fat phase. When this is cooled, for example to 20°F, this liquid fat portion becomes solid, and in so doing sets up sufficient stresses in the covering to break the center. Dark chocolate with much less liquid phase at normal temperatures does not give this trouble.

3. Tempering and cooling.

During enrobing and subsequent cooling similar stresses will be set up in the chocolate if it is untempered and subjected to severe cooling. Low temperatures and rapid cooling must always be avoided with chocolate-covered aerated centers.

MARSHMALLOWS

Marsh mallow (*Althaea officinalis*) is of the hollyhock family of plants and its root yields a mucilaginous juice that has demulcent properties. The juice was originally compounded with egg and sugar to produce an aerated product. It was a pharmaceutical medicament used for treatment of chest complaints and eventually was recognized as an attractive candy.

Marshmallows today do not contain the root juice and aeration is obtained by the inclusion of egg albumen, gelatin, hydrolyzed milk protein, gum arabic, or other whipping agents in a sugar/glucose syrup.

The texture depends on the type of aerating agent and the final moisture content, which may range between 12 percent and 18 percent. Additionally, particularly in the United States, there are "stoved" marshmallows that may be dry and fairly hard. They are used in cookery recipes and flour confectionery.

The formulation and process of some mallows are such that the syrup phase concentration may not reach the minimum of 75 percent. This, together with the fact that ingredients such as egg albumen and gelatin may have significant microbiological counts, renders the confection liable to fermentation, mold growth, or infection by some

liquefying bacteria. Another factor, mentioned earlier in the chapter, is possible flavor oxidation due to the intimate contact of air cells with the substance.

The manufacture of marshmallows is frequently a cold process after preparation of the base syrup. Even when cast into starch, which gives superficial drying, the remaining center of pieces may have too high a moisture content.

Marshmallows can be made in batches by whipping under normal atmospheric pressure or under increased pressure. They may be pressure whipped in continuous machines.

Batch processing may take place in two ways: In the one-step process, the syrups and solutions of the whipping agents are mixed and beaten to a foam of required density. In the two-step process, the whipping agent is beaten separately to a light frappé and the syrup, prepared separately, is added to this, followed by beating to the required density.

The aerated product may be cast into starch on a Mogul machine or extruded as a rope onto a long bed of starch. The extruded rope is chopped into lengths, the formula being adjusted to give rapid setting.

The following formulations and processes are examples only. The variations possible and, in fact, employed in the manufacture of marshmallows, are very large indeed and detailed information is given by Jackson (1973) and Minifie (1971).

A typical method for the manufacture of marshmallows is as follows:

Gelatin after soaking is dissolved in hot water.

Egg albumen is soaked in cold water to dissolve, strained through a fine sieve, and added to the gelatin solution.

Sugar, glucose and invert sugar are dissolved in water to a syrup and boiled to the appropriate degree.

The gelatin/egg solutions are placed in a beater, which can be of the planetary or horizontal type, and the syrup added after cooling to 71°C (160°F). The mixture is then beaten to a fluid foam and the density checked. The foam, which should be at about 50°C (120°F), is then ready for casting into starch. For marshmallows, the starch must be dried to a moisture content of 4 to 6 percent and the temperature of the starch should preferably be below 100°F, and if these conditions are not observed, the marshmallow foam may partially soak into the starch and produce starch crusts on the pieces. Marshmallows may be made in a pressure whisk using the same procedure as above but the density is controlled by beating at a given

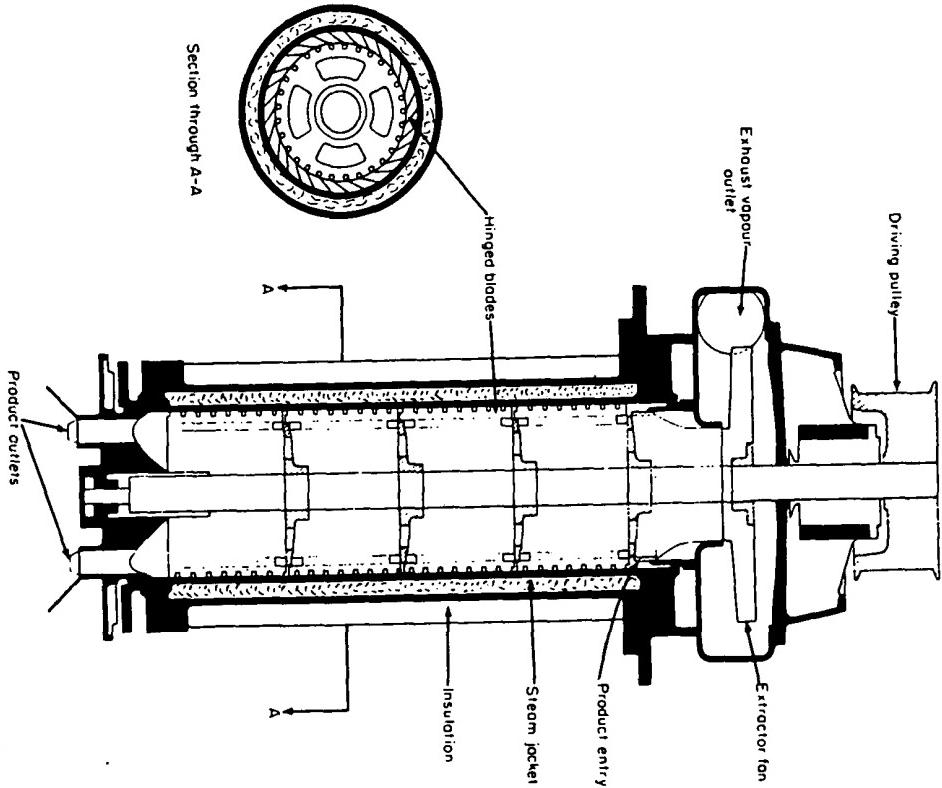


Fig. 19.26. Microfilim Continuous Cooker

Baker Perkins, Peterborough, England

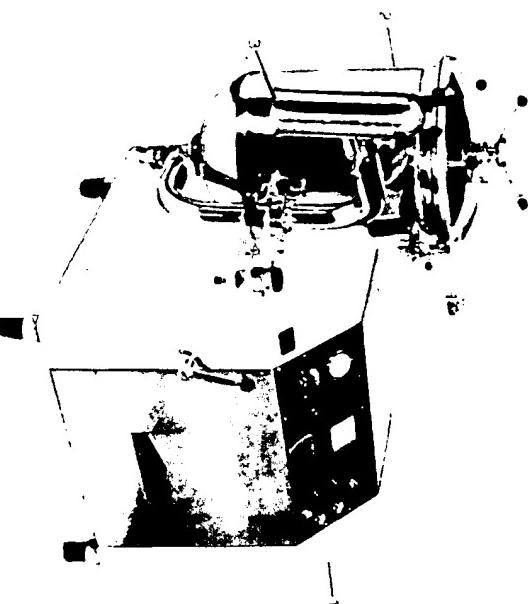


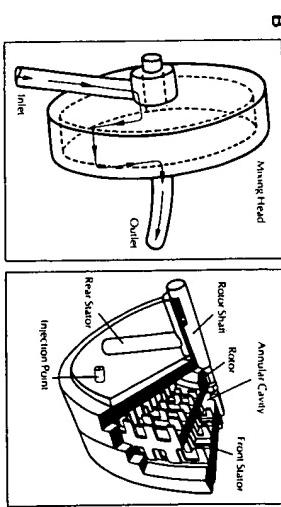
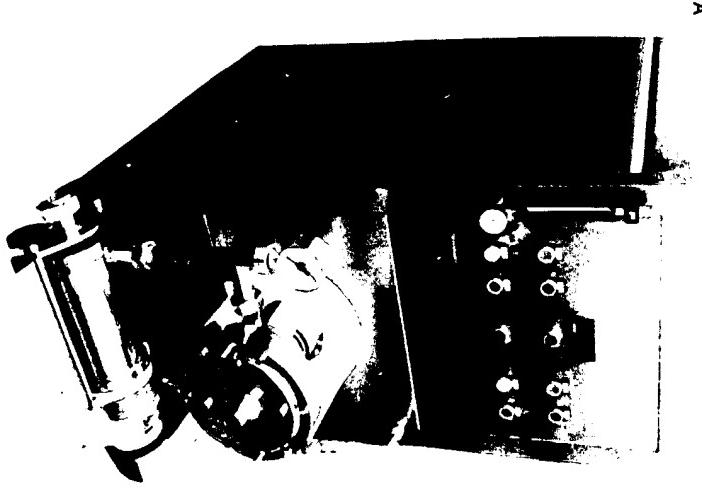
Fig. 19.27. Morton Air Pressure Whisk

Morton Machine Co., Motherwell, Scotland

pressure. A pressure beating machine that has been used for many years is the Morton whisk (Fig. 19.27). The air pressure and time of whipping is determined by the control unit (1). The syrup/whipping agent is rapidly mixed in the pressurized container (2). The foam mix is discharged automatically through (3) by means of the internal pressure in the container. Beating under pressure, followed by release to atmospheric pressure, gives maximum expansion of the foam and minimum density.

It is also possible to use a continuous pressure beater where the syrup/gelatin/albumen mixture is held in a tank for feeding to the beater.

A machine that has been used very successfully is the Oakes continuous automatic mixer (Fig. 19.28). The essential part of this machine is the high shear mixing head, which consists of a rear stator, a rotor, and a front stator. The delivery of syrup mixture, air,

Fig. 19.28. A. Oakes Continuous Mixer
B. Diagram of Mixing Head

Vicars Group Ltd., Newton-le-Willows, England

and pressure is controlled automatically and the aerated product is delivered continuously through a back pressure valve.

Other continuous machines are the Turbotmat (Otto Hänsel), Air-O-Matic (Weesp Holland), and the Whizolator. This last machine, developed by the late J. Alikonis and the Beich Company, Bloomington, Ill., is interesting because it contains no moving parts at the mixing stage. Air under pressure and the whipping syrup are fed through spiral jet valves that give all the dispersion needed for production of a stable foam.

A typical recipe for marshmallow that can be poured into starch and then enrobed or sugar/starch dusted, is as follows:

1. Gelatin	340 g (12 oz.)	soak and dissolve by
Water	1.58 kg (3½ lb.)	warming.
Egg albumen	113 g (4 oz.)	soak, dissolve, and mix
Water	0.68 kg (1½ lb.)	these two solutions.

2. Sugar	6.35 kg (14 lb.)	Heat to dissolve, then
Glucose syrup	2.72 kg (6 lb.)	boil to 112°C (233°F).
Water	2.26 kg (5 lb.)	

3. Invert sugar	2.7 kg (6 lb.)	Add to boiled syrup 2.
4. Flavor as required.		

Cool the mixed syrups (2 and 3) to 71°C (160°F) and add these to the gelatin/egg solutions (1) and beat to the required density, which should be 0.40 to 0.50.

Pour at about 49°C (120°F) into starch at 4 to 6 percent moisture content and leave to dry and set for 16 to 24 hr in a warm, dry atmosphere (27°C/80°F).

The texture and density of marshmallow can be varied greatly by adjustment of the quantity of egg albumen and gelatin and by the inclusion of other gelatinizing agents or gums. The quantity of water affects the density of the whip, as will the pressure applied in the machines described above. Mallows may be made with gelatin alone provided setting of the gelatin is controlled in the process.

The following gelatinizing agents may be used to impart different textures to marshmallows:

Agar. This is dissolved in boiling water, the solution strained and cooled, and then added to the albumen solution. This takes the place of the gelatin and is used in the proportion of about 1 to 2 oz per 10 lb of marshmallow. This gives a firm set to the mallow.

Gum arabic. This gum is dissolved in cold water by soaking and occasional stirring, then strained and added in the place of the

gelatin solution. Gum arabic is usually added in fairly strong solution (25 to 50 percent) and produces a tenacious, stringy confection.

Pectin. Pectin is an ingredient not often used in mallows but it gives an unusual texture and has been applied to recipes that include fruit pulp. The syrup of sugar and glucose is prepared as before. The fruit pulp is added to the hot syrup followed by the liquid pectin, which is high methoxyl pectin solution prepared from powdered pectin or a pasteurized liquid pectin (not preserved with sulfur dioxide). This mixture is then added to the gelatin solution and the whole beaten to a foam. This pectin/gelatin/syrup must be at a temperature of 71 to 82°C (160 to 180°F) for beating and pouring so that premature setting of the pectin does not occur (see "Pectin"), and it may be necessary to adjust the pH for the optimum gel formation. This recipe gives a short jellylike texture with pectin about 1 percent of the mallow.

Short Mallows

A short texture mallow can be made by the addition of powdered (icing) sugar to the beaten foam. In this recipe, the syrup base is prepared with a higher sugar content, for example

Sugar	6.35 kg (14 lb)
Glucose syrup	1.36 kg (3 lb)
Invert sugar	0.9 kg (2 lb)
Water	2.26 kg (5 lb)

The mallow is otherwise made as for the typical recipe previously given and the icing sugar (2 lb) mixed into the foam for just long enough to give complete dispersion. Over mixing must be avoided.

Kisses, Angel Kisses

These confections consist of a very light density mallow (0.25) extruded through nozzles onto a wafer cookie. The mallow so prepared is piped warm and will stand up as a dome 1½ to 2 in. high and this is covered with chocolate or coating, but the bottom is usually left uncovered.

The method for preparation of this mallow is to beat the albumen (or substitute) solution with gelatin solution and icing sugar to a light stiff foam and then add to the sugar/glucose syrup and mix

slowly until completely incorporated. Overmixing will increase the density.

1. Egg albumen	85 g (3 oz)	Dissolve the egg and
Gelatin	43 g (1½ oz)	gelatin in part of the
Water	0.9 kg (2 lb)	water and mix.
Then add icing sugar	0.9 kg (2 lb)	
Beat at high speed until the lowest density is obtained.		

2. Sugar

Sugar	1.8 kg (4 lb)	Dissolve and boil to
Glucose syrup	1.36 kg (3 lb)	112°C (233°F).

Water

0.68 kg (1½ lb)

Cool

to

71°C (160°F)

and add to 1 with slow mixing.

Marshmallows on cooky bases covered in chocolate, or more frequently compound coatings, have become a very popular confectionery piece. Often they are combined with a fruit jelly deposit before coating. They do have a limited shelf life, which is considerably longer than most flour confectionery items but less than sugar or chocolate confectionery such as caramels and soft nougat bars. The mallow deposits are denser than with the Angel kisses mentioned above. Often they are combined with a fruit jelly deposit before coating.

Sanitation in the Production of Marshmallows

The subject of sanitation and spoilage is frequently mentioned throughout this book. The importance of this in relation to good shelf life and quality cannot be overemphasized.

The freshly made marshmallow is a delectable sweet, but careful examination of many recipes given in textbooks will reveal that they must have a short shelf life. In constructing a recipe for mallow, the following points should be checked:

Moisture Content and Concentration of the Syrup Phase It will be noted from a rough calculation of the moisture content of a mallow syrup before beating that it is often over 30 percent. This will give a syrup phase concentration well below 75 percent in the whipping mixture when it is poured into starch. The effect of the dry starch and low-humidity storage will reduce the moisture considerably and may even bring the syrup phase concentration to 75 percent or above. This may not apply to large mallow pieces, and particularly to the center portion. Although after a period moisture will distribute itself, the center may be at a low concentration long enough to bring about

microbiological deterioration. In most mallow recipes, the sugar/glucose/invert ratio is such that a sugar solubility can be obtained that will give a 75 percent minimum soluble solids if the moisture content is low enough. It is particularly important, therefore, to check moisture and soluble solids through the process. Where no starch drying or stoving is used, as would be the case if poured into a chocolate shell, the soluble solids of the mallow must be over 75 percent at this stage.

Some mallow recipes such as kisses and those used for fillings and topping for flour confectionery are not intended for long shelf life and are made to very light densities and high moisture contents.

Microbiological Deterioration Apart from any defects arising from incorrect syrup phase concentrations, the ingredients and process invite microbiological action. Both egg albumen and gelatin may be sources of microorganisms and the low temperatures used in many of the processes do not destroy these.

Reference has been made elsewhere to the pasteurization process for egg albumen. This has been usefully applied to egg/gelatin syrups in continuous mallow manufacture for depositing into chocolate shells. Egg albumen is not subject to coagulation at so low a temperature in syrup as it is in water and the egg/gelatin/syrup can therefore be pasteurized by holding it at 71 to 74°C (160 to 165°F) for 15 to 20 min with *very slow stirring*. Local overheating must be avoided as coagulated egg films appear on the surface of tanks and pipes. Rapid stirring will create an aeration in the syrup that affects the syrup density sufficiently to upset metering accuracy in continuous plant.

The introduction of fermenters into mallows must be avoided at all cost and scrupulous plant hygiene is very necessary. The need for good plant hygiene is again emphasized. Egg and gelatin syrups are very vulnerable to microbiological attack. A regular system of *cleaning and sterilization of containers, tanks, pipelines, and machines must be operated. With egg syrup, which may coagulate and form layers on the interior surfaces of plant equipment, washing out first with tepid water is necessary. This is followed by steaming and circulation of a bactericidal detergent.*

Flavors—Antifoam Effect—Deterioration In a marshmallow, the air in the bubbles is in intimate contact with the syrup film around the bubbles, and this oxygen in the air bubbles has a maximum opportunity of reacting with ingredients in the syrup film.

Certain flavors and essential oils, lemon and orange oil particularly, are very susceptible to oxidative rancidity when in thin layers and develop objectionable resinous flavors. Careful selection of flavors for mallops, in fact, for any aerated confection, is very important. It is useful to carry out oxygen-absorption tests on natural essential oils before using them for aerated products. Terpeneless oils and synthetic flavors usually keep better than the original essential oil and natural fruit concentrates are generally satisfactory.

Most essential oils and many other flavors that contain oily or fatty acid components have distinct antifoam properties and this can have a marked destructive effect on the aeration. In the worst cases, the mallow center will separate into a syrup layer and a coarse foam with little substance after several weeks. Where flavors that have an oily base must be used, they are better emulsified. Alternatively, powder "locked" flavors may be included. It is now a practice in the manufacture of some aerated foods to use an inert gas (nitrogen) instead of air for preparation of the foam. This is readily applied in the continuous-pressure machines previously described.

Graining—Drying Out With the exception of short mallops where crystallization has been intentionally encouraged by the addition of icing sugar, the syrup phase composition should be such that no sugar crystals form on storage.

Marshmallows that are not chocolate coated will dry out under most conditions of storage, and in severe cases the drying will start crystal formation because the syrup phase becomes more concentrated. Drying out will also make the mallow tough.

Uncoated mallops are now generally wrapped in moistureproof film bags. Various proposals have been made to retard drying without making them hygroscopic. Glycerol and sorbitol solution (70 percent) are used and these retard crystallization as well but appreciable amounts have to be included to be effective, and this is expensive. The pectin mallops mentioned previously show remarkably good keeping properties as pectin gels generally retain moisture well.

A proportion of invert sugar in the syrup phase helps, but an excess may bring about dextrose crystallization.

NOUGAT, SOFT NOUGAT (MONTELIMART, NOUGATINE)

Nougat, traditionally, is a French product made from honey and egg white, beaten to a frappé. Nuts and dried fruit are added to give the product called montelimart.

Originally, nougats were hard and chewy but of recent years soft nougats (sometimes called nougatines) have become very popular. They are higher in moisture content, lighter in density, and contain such powder ingredients as cocoa, milk powder, lactose, malt, and icing sugar, which have a shortening effect. Fat and emulsifiers are also included to overcome stickiness, and these aid cutting and forming.

In the hard nougats, the sugars are totally in solution, whereas in the short, softer nougats, there is a syrup phase interspersed with the solid substances (above) and the fat. Compare this with caramels and fudge.

In the production of the short nougats, the proportion of sugar to glucose syrup is higher and icing sugar is added to promote crystallization in the mixture. Alternatively, fondant may be added in the later stages of mixing.

There are numerous formulations possible and they may be made by a batch or continuous process and, as with marshmallows, mixing of the whip and syrup may be done under pressure.

The following describes batch, continuous, and pressure systems but there are many variations.

Certain essential factors must be observed and some of these have been mentioned in connection with marshmallows. They apply particularly to continuous process.

Egg Syrups

These should be pasteurized and used within a short period after making—a few hours maximum. Never leave overnight in a warm place. Vessels, pipelines, and pumps must be sterilized after each production period. Wash first with tepid water, followed by boiling water or steam—this avoids films of coagulated egg coating the equipment. If the equipment is to be out of action for a period, wash out with bactericidal detergent.

Cocoa Powder, Milk Powder, Spice Flavors

These should be free from lipase and have low bacteria counts. Cocoa and spices particularly may be suspect. The temperatures of processing may not be sufficient to destroy lipase. A method that has been used to treat cocoa and spices is to make a slurry in a heat-stable vegetable oil (Durkee 500) and heat to 110°C (230°F). This procedure also aids dispersion of the cocoa powder and prevents lumping.

Fats

Lauric fats (coconut and palm kernel oil), which are often used, are vulnerable to soapy rancidity, from lipase action, and it is better to use nonlauric fat if the texture is acceptable. When adding fats to aerated products, use the minimum mixing time in keeping with dispersion. Fat destroys aeration.

Examples of Formulation and Processes**Soft Nougat****Using planetary beater:**

1. Egg albumen (or substitute)	0.25 lb	2. Sugar	25.0 lb
Water	3.0 lb	Glucose syrup (low conversion)	25.0 lb
Icing sugar	5.0 lb	Water	10.0 lb
Dissolve egg in water. Add icing sugar. Beat at high speed with wire whisk.		Dissolve sugar in water. Add glucose syrup. Boil to 141°C (286°F). Add to 1 in thin stream. Fat and fillings (chopped nuts) may be added if required. Spread onto cooling table and cut when set.	
2. Sugar	13.0 lb	With the ever increasing popularity of the soft nougats, mostly sold in bar form and chocolate covered, large-scale batch and continuous equipment has been constructed.	
Glucose syrup	20.0 lb	A typical example is the twin batch machine Ter Braak Preswhip (Fig. 19.29). This machine provides a metered delivery of sugar and glucose followed by dissolving and cooking to a given temperature. The solution of whipping agent is prepared separately. The syrup and whipping agent are delivered to a mixing vessel, which is pressurized. Mixing is standardized to a given pressure time and temperature.	
Water	4.0 lb	After beating, the aerated mixture is delivered to a mixer in which the fat and other ingredients (flavor, cocoa powder, milk powder, icing sugar, preserved fruit) are incorporated. This must be a short	

Dissolve sugar in water. Add glucose syrup. Boil to 127°C (260°F). Add syrup in a thin stream to the whip using low speed and the flat beater.

3. Cocoa powder (10 to 12 percent fat)	2.0 lb	2. Sugar	25.0 lb
Malt powder (diastase free)	2.0 lb	Glucose syrup (low conversion)	25.0 lb
Nonfat-milk powder	2.0 lb	Water	10.0 lb
Icing sugar	1.5 lb	Dissolve sugar in water. Add glucose syrup. Boil to 141°C (286°F). Add to 1 in thin stream. Fat and fillings (chopped nuts) may be added if required. Spread onto cooling table and cut when set.	

Mix powders dry and stir gradually into 1 plus 2.

4. Fat

1.0 lb

Melt at low temperature and add to mixture with slow mixing and minimum time for dispersion. Spread onto cooling table and cut when set.

Cocoa may be dispersed in fat as mentioned previously.

Hard Chewy Nougat**Using planetary beater.**

1. Egg albumen (or substitute)	0.25 lb	2. Sugar	25.0 lb
Sugar	4.5 lb	Glucose syrup (low conversion)	25.0 lb
Water	3.5 lb	Water	10.0 lb

Dissolve egg in 2 lb water. Dissolve sugar in 1.5 lb water (hot). Cool and add to egg solution. Beat at high speed using wire whisk.

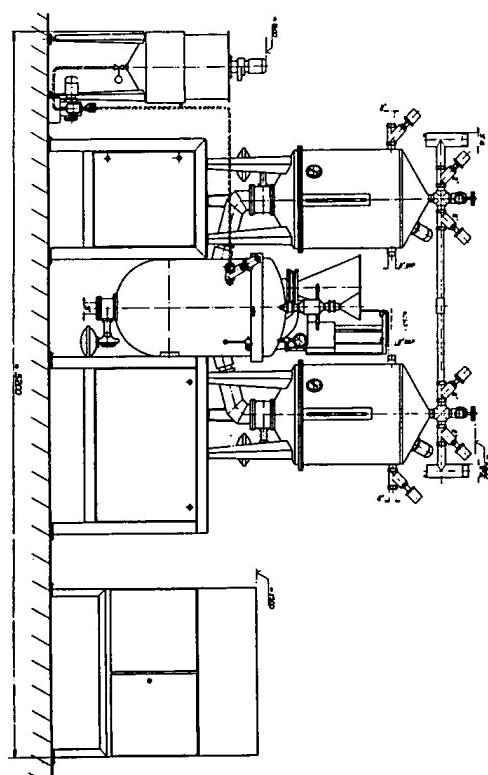


Fig. 19.29. Preswhip Air Pressure Whisk

Bepex-Ter Braak, Rotterdam, Holland



The basis of this product is a sugar/glucose syrup combination and a gelatinizing agent, which may be gelatin, gum arabic, maltodextrin, or a modified starch. A proportion of fat is included to improve texture and prevent excessive stickiness in the mouth.

The mixture after compounding is pulled, which again contributes to the texture. These candies have a lasting effect in the mouth, somewhat like chewing gum but without the presence of the insoluble gum base. Texture is also modified by the inclusion of fondant, which has a shortening effect.

The following formulation and batch process are representative.

Base Syrup	
Sugar	14 lb
Water	5.0 lb
Glucose syrup (low conversion)	20 lb
Vegetable fat (melting point 33°C approx.)	26 oz
Lecithin	3 oz

Dissolve sugar in water and add glucose syrup. Cook to 120°C (248°F). Disperse lecithin in melted fat; add to syrup, and mix thoroughly in a planetary mixing machine.

Gelatin Solution	
Gelatin (130 Bloom)	4.5 oz
Water	9.0 oz

Soak gelatin until swollen, then warm to dissolve (70 to 80°C). Cool syrup to 90°C (194°F) and then add the gelatin solution. Mix slowly and pour onto cooling table, where it is "tempered" by folding as with hard candies. Add, during the mixing process or on the table, citric acid (monohydrate), 3.5 oz, for flavor and color.

If shorter candies are required, fondant is added at the same time as the syrup is mixed with the gelatin solution (fondant, 1 lb 2 oz).

The tempered, flavored mass is pulled for from 3 to 10 min according to the final texture required, and then formed into pieces by pressing or extrusion.

As with many other confectionery variations are large.

Table 19.3 gives the ranges of ingredient quantities. Popular flavors are the essential oils—lemon, orange, lime, peppermint—and combinations of natural and synthetic fruit flavors.

Since these candies are partly aerated, the flavors used must be resistant to oxidation (see "Marshmallows"). Large-scale equipment is now available for making this type of

FRUIT CHEWS

This type of confectionery has achieved much popularity of recent years—particularly as summer candies, because they are mostly fruit flavored and acidulated.

TABLE 19.3. CHEWING SWEETS COMPOSITION

Percent	Range	Average
Moisture content	5.3-7.3	6.5
Acid (citric)	1.0-1.6	1.3
Fat	2.8-10.4	5.8
Gelatin (or other agent)	0.5-2.5	1.4
Sugar	36.7-46.1	42.1
Glucose	45.0-60.0	49.5
Proportion sugar/glucose syrup	1/0.9-1/1.7	1/1.2

and these are described in greater detail in the ingredient section of the book.

Various other gums are used in the food industry but to a lesser extent in confectionery. Among these are guar and carob (locust bean) gums—which are seed products. Gum tragacanth is an exudation from the Astragalus bush. These gums are used as mucilages for thickening and for stabilizing emulsions. Some are used in chocolate spreads or syrups. Xanthan gum a natural gum prepared by biosynthesis is similarly used.

Then there are the methyl celluloses that produce great bulk when water is absorbed—they find application in certain dietary and slimming confectionery. Chicle gum is a natural latex used in chewing gum. Modified starches are being used more and more in the manufacture of jellies. High amylose starch combined with pressure cooking will produce jellies with much reduced setting time.

In the manufacture of jellies, particularly the softer jellies, certain general precautions must be observed.

Solution of the Gelling Agent

Obviously, the gelatinizing material must be properly dissolved and, if necessary, the solution strained to remove any extraneous material. Some, like gelatin, agar, and gum arabic, need soaking in cold water first and when this is done care must be taken to see that the solid does not consolidate at the bottom of the soaking vessel. Careful stirring during soaking is necessary and this applies particularly to powdered gelatin and agar. Gelatin solutions must be warmed and not boiled to dissolve. Gum arabic needs slow dissolving in warm conditions and excessive stirring or boiling results in an unmanageable foam. Agar must be boiled to dissolve, but this must not be prolonged. Unmodified starches require boiling to dissolve but first must be dispersed as a thin slurry with cold water. Some modified starches are soluble in cold water. Amylose starch requires pressure cooking to dissolve. Pectin needs special care in dissolving—the powder must be carefully dispersed through the solution and the pectin/sugar/acid balance must be correct (see "Pectin").

Syneresis, pH, Gel Breakdown

Syneresis is the property some gels have of exuding syrup (sweating) after a period of storage—it is detrimental to sales of the product as it not only spoils the eating quality but causes sticky

TABLE 19.4. GELLING AGENTS—ORIGIN AND USES

Type of gelling agent	Origin	Use
Gelatin	A protein of animal origin extracted from bones and skins	General. Must not be boiled. To be added to warm syrups for setting on cooling.
Agar Alginates}	Extracted from various seaweeds	Various. Produce short neutral jellies. Weakened by boiling in acid solutions.
Gum arabic or acacia	Exudation from trees	Used to produce hard gums and as an extender and thickener in products such as marshmallows.
Starch and modified starches	Seeds and various roots	These have completely or partly replaced other gelling agents in gums, Turkish delight, glazes, citrus and apple pomace. Used largely in acid fruit jellies but low methoxyl pectin is used in neutral jellies.
Pectin		

syrup to adhere to the wrappings. This defect arises in agar jellies from excess acid addition and in pectin gels by incomplete solution of the pectin, overacidification, or as a result of depositing below the setting temperature.

Some starch gels are prone to syneresis and it is customary to include another gelling agent as a stabilizer. High amylose starch gels generally are not affected. All jellies may exhibit this defect as well as granulation if the finished confectionery product is mixed after the gel has started to form. Granulation occurs if a jelly confection is poured into starch, chocolate shells, or other molds below the setting point of the mixture and in any mixture, before depositing, the setting point temperature must be known.

Gums

Hard Gums This is another confectionery product that has been handed down from the pharmacist who combined medicaments with gum arabic, sugar syrups, and honey. The presence of gum ensured slow dissolving, a feature particularly useful for treatment of throat infections.

Most recipes for gums rely on gum arabic or a mixture with gelatin as the gelatinizing agents but certain modified starches are now also used. A typical recipe and process is as follows:

Gum arabic	12.7 kg (28 lb)	Soak with gentle warming and stirring until the gum is dissolved. Strain through a fine sieve to remove foreign matter.
Water	11.3 kg (25 lb)	

Sugar	6.8 kg (15 lb)	Dissolve and boil to 124°C (255°F)
Glucose syrup	1.8 kg (4 lb)	
Water	2.26 kg (5 lb)	
Glycerol	0.45 to 0.68 kg (1 to 1½ lb)	May be added to prevent overdrying in the hot room.

The syrup mixture is poured into the gum solution and gently mixed. A certain amount of scum will rise on standing and this should be skimmed off. A second heating will cause further scum and this is also removed and the clear gum solution drawn off for

deposition in starch which should be dried to 4 to 5 percent moisture. The gums are then dried for six to ten days in a dry, hot room at 49°C (120°F) until the required texture is obtained. They are then removed from the starch by sifting and well brushed to remove as much starch as possible. The gums are then subjected to a glazing process by placing them on wire sieves and steaming, which gives a glossy surface, but this must not be overdone or the surface will become unduly softened. They are then subjected to a further drying process. A continuous machine is manufactured for this process and the original practice of "oiling" the gums is not necessary.

The above basic recipe requires flavor and acid additions and a variety of substances may be used. Lemon, orange, and lime oils give good citrus flavors and concentrated juices are very popular for other fruit flavors. Licorice juice, honey, and various substances such as menthol, eucalyptus, and aniseed are employed for throat gums.

Soft Gums and Pastilles With the softer gums and pastilles it is usual to include gelatin as well as gum arabic and the glucose syrup content is higher; otherwise, the process is very similar. A recipe used for fruit pastilles is as follows:

Sugar	4.1 kg (9 lb)	Dissolve and boil to 121°C (250°F).
Glucose	4.1 kg (9 lb)	
Fruit juice concentrate or fruit pulp	3.1 kg (7 lb)	
Water as required depending on concentration of juice or pulp and some citric acid may be used.		

Gum arabic	3.1 kg (7 lb)	Dissolve and strain.
Water	3.1 kg (7 lb)	
Gelatin	0.45 kg (1 lb)	Soak and dissolve. Then add to gum solution.

Add the gum/gelatin solution to the syrup and mix well, then pour into dry starch and dry in a hot room until the correct texture is obtained.

Pastilles are normally sanded with granulated or graded sugar. This process starts with steaming the units after removal from starch as for hard gums, but before drying they are sugar coated in a rotary

drum and the excess sugar removed by sieving. The sugared pastilles are then dried off on a wire mesh, the sugar forming a layer over the surface. After sugaring, a second steaming is given before drying and this gives a more continuous sugar coating.

Starch Jellies

Starch, in its various forms, has been used for many years for making jellies. In its original unmodified form (e.g., corn flour, wheat flour), it was used for making Turkish delight. This entailed long boiling in water or dilute syrup (4 to 5 hr) in order to burst the starch grains.

The first special starches to be produced were the boiling starches. These are chemically softened by acid treatment and are still used a great deal in confectionery. They are satisfactory for open-pan boiling

as well as for pressure or jet cooking. Genetically modified starches have been developed of recent years. High amylose starch is the most important, and this requires high-pressure/temperature cooking. This results in a great saving in time and heat and jellies prepared this way have become very popular, particularly in the United States.

They are produced in a variety of flavors and textures. They may be sugar sanded, steamed, dried, or oiled, and used as centers for panning, as in jelly beans.

These different starches are described elsewhere (see "Starches"). The equipment for processing may be the steam-jacketed pan, the Chemetator, or the jet cooker (see Figs. 19.31 and 19.32).

Chemetator® A premix is made that contains just sufficient water to

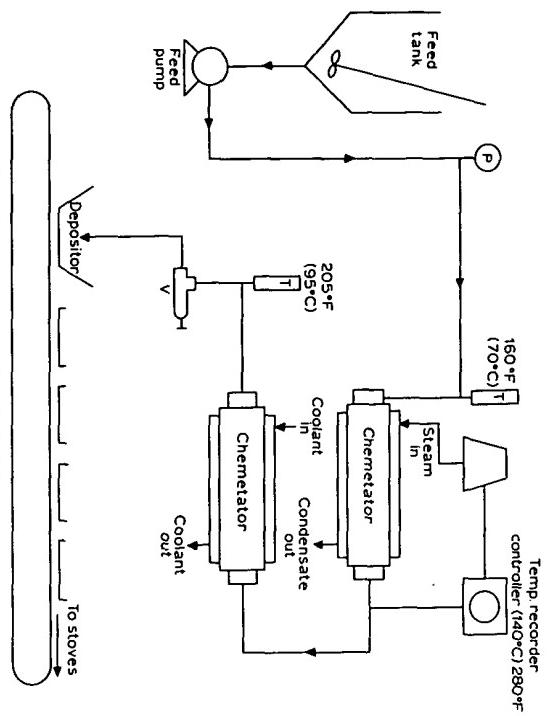


Fig. 19.31. Continuous Starch Jelly Production

P = Pressure Gauge

V = Back Pressure Valve

T = Thermometer

Chemtech, Reading, England

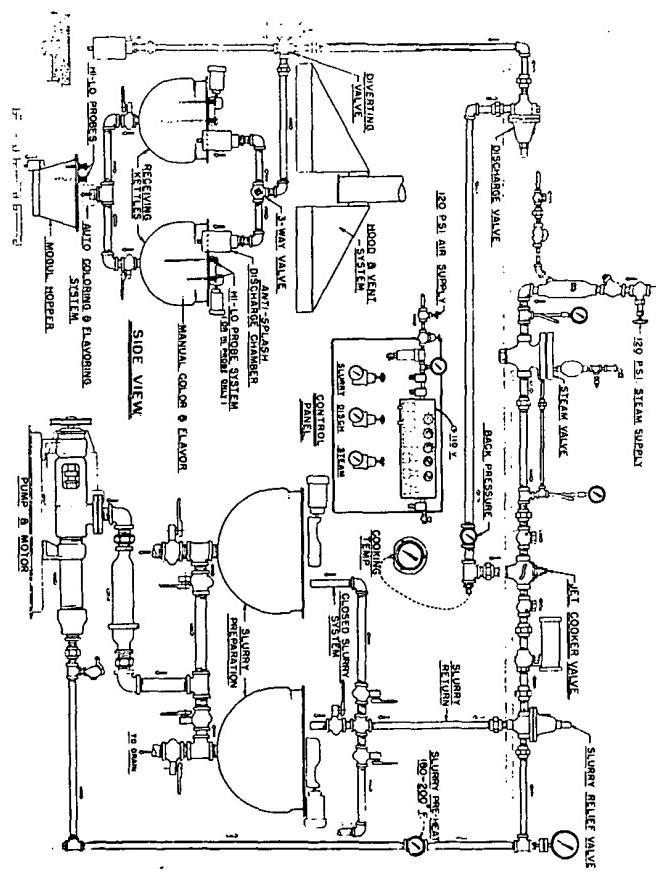


Fig. 19.32. Typical Flow Diagram Jet Cooking System

A.E. Staley Mfg. Co., Decatur, Ill.

cook and dissolve the ingredients and is only 1 to 2 percent above the moisture content of the final cooked jelly. This premix is heated to 70°C (160°F) and then pumped to the Chemetator unit, where it is heated to 140°C (284°F) under pressure. The bladed shaft, which spreads the slurry over the internal heating surface, ensures even cooking.

From the cooker the slurry is fed to the cooling Chemetator and then through a back pressure valve to the depositing system.

Jet Cooking A premix slurry is prepared according to the formulation required. This slurry is preheated to 82°C (180°F) and fed to a jet chamber, where it is cooked continuously at about 80 lb/in² pressure at 140°C (284°F). The discharged cooked product is flavored and colored, either in a separate pan or continuously in a pipeline.

Process and Formulation Details

Open Pan Boiling Open kettle processing has been used for many years and the starch/sugar slurry is cooked in steam-jacketed pans with mechanical stirrers. These must sweep the surface thoroughly so that no film accumulates, thereby forming an insulating layer that retards boiling.

In this method of cooking, thin boiling starch is used with sufficient water to ensure that the starch grains are burst. If insufficient water is used and sugar is present, the sugar retards the starch gelatinization.

Open Pan Boiling (typical recipe and process)

Sugar	22.6 kg (50 lb)
Glucose syrup 42 DE	28 kg (62 lb)
Invert syrup	5.4 kg (12 lb)
Thin boiling starch	7.25 kg (16 lb)
Water	56.7 kg (125 lb)
Citric acid	14 g ($\frac{1}{2}$ oz)
Flavor	{ as required
Color	

Dissolve sugar, corn syrup, and invert sugar in half the water and bring to boil. Prepare a slurry of the starch and the remainder of the water (cold). Pour slurry in a thin stream into boiling syrup. Boil to 76/78 percent solids by refractometer. Deposit in starch.

Pressure Cooking The first developments in the pressure cooking

process used scraped surface heat exchangers of the Chemetator type. Later, the steam injection principle was invented where steam under pressure is continuously injected into the starch/sugar slurry through radially aligned nozzles. This gives very rapid mixing and cooking. The disadvantages of open-pan cooking are overcome by pressure cooking. A large excess of water must be used to cook starch in an open pan, with a consequent long cooking period.

With pressure cooking at a high temperature, the starch can be gelatinized with much lower water contents and in the presence of sugar. With the steam jet method, small amounts of slurry are cooked continuously in the jet chamber in a matter of seconds. A diagram of the system is shown in Fig. 19.32.

Pressure-Cooked Starch Jellies

Formula A—(Chemetator principle) using thin boiling starch;

Granulated sugar	18.1 kg (40 lb)
64 DE corn syrup	27.2 kg (60 lb)
Thin boiling starch	5.9 kg (13 lb)
Water	7.7 kg (17 lb)

Put water in the slurry kettle. Then add the corn syrup followed by the other ingredients. Mix well and preheat to 82°C (180°F), being careful not to boil off moisture at the pan edges. The sugar should be in the solution and the slurry is ready for pressure cooking at 138°C (280°F).

Formula B—(Jet cooker) using high amylose starch;

Granulated sugar	18.1 kg (40 lb)
64 DE corn syrup	27.2 kg (60 lb)
Thin boiling starch	1.8 kg (4 lb)
High amylose starch	27 kg (60 lb)
Water	5.4 kg (12 lb)

Prepare slurry as for formula A but preheat to 93°C (200°F) and pressure cook at 168°C (335°F).

In each case, the cooked product is run into a suitable mixer for incorporating the flavor and color. It is also possible to feed these continuously into the exit pipeline. Note the higher cooking temperature for the high amylose starch.

Turkish Delight This very popular candy has a very long history originating in the East where it was made from honey and flour and flavored with rose otto, which is still the accepted flavor for this product.

Turkish delight recipes are of two types—one is poured onto tables to cool and set, after which it is cut up into cubes and dusted with

fine sugar. It is sold in this fashion, usually in exotically designed boxes. The second type is poured into starch and after removal is covered in milk chocolate.

Starch is an essential ingredient of Turkish delight as it gives the opacity characteristic of the traditional article.

Turkish delight prepared from starch alone does not have a very good shelf life. It may suffer from syneresis and will dry out if not chocolate covered. Gelatin or agar may be used to improve the properties of the jelly.

Low methoxyl pectin with boiling starch has proved very successful with Turkish delight for starch casting. Typical recipes are given below, but that containing LM pectin is more appropriately given in the section on "Pectins."

1. Starch Only

Thin boiling starch	2.26 kg (5 lb)
Water	13.6 kg (30 lb)

Mix cold to a slurry and then bring to the boil with continuous mixing and boil for 2 min. Then add:

Sugar	13.6 kg (30 lb)
Glucose	3.6 kg (8 lb)
Invert sugar	0.90 kg (2 lb)

Continue boiling until the solution reaches a soluble solids of 78 to 80 percent when it is poured onto cooling tables. Flavors, which should include rose otto or synthetic rose flavor and a small amount of citric acid, must be added after boiling has ceased.

2. Starch with Additional Gelatinizing Agents.

Use procedure as

recipe 1, and then add, after boiling has ceased:

Gelatin 340 g (120 oz) (previously soaked in water)

Alternatively, agar may be used and a solution prepared by boiling as previously described and added to the base syrup before boiling is completed. This recipe may be boiled to a lower soluble solids content (75 to 76 percent).

Agar and Gelatin Jellies

Both agar and gelatin are used a great deal in the production of confectionery jellies. The final jelly is short if produced from agar and rather tough and rubbery from gelatin, but the texture from gelatin

depends much on the quantity used. Pectin jellies, on the other hand, are tender and readily dispersed in the mouth.

The properties of agar and gelatin are described in the ingredient section of this book.

Preparation of Gelatin Jellies The type of gelatin used for confectionery jellies may be powder, sheet, or granule. The powder can be dissolved fairly quickly in warm water but care is necessary to prevent it from consolidating on the bottom of the vessel. Gentle stirring is necessary. Sheet or granule gelatin must be soaked in cold water and it will absorb as much as ten times its weight, but it is usual to soak in an equal amount of water. Care in this process is necessary; prolonged soaking in warm conditions will encourage microbiological spoilage. Use clean, sterilized covered vessels and soak not more than 12 to 18 hr. The strength of gelatin is recorded by its Bloom value, which may vary from 50 to 300. In confectionery, that usually employed for jellies ranges between 180 and 220. The proportion of gelatin in a jelly varies from 4 to 12 percent, depending on the texture required. Gelatin solutions must never be boiled, and the gelatin solution must be added at the end of the syrup boil after cooling to below 80°C (176°F). Similarly, any acid must be added at the latest stage. Heat and acidity rapidly degrade jelly strength.

The following is an example of the formulation and manufacture of a gelatin jelly. Many variations are possible. In the manufacture of fruit jellies, the mixing of some fresh fruits with gelatin syrups must be avoided. Pineapple and papaya, for example, contain proteolytic enzymes that rapidly destroy gelatinizing powder. While this problem is most likely to occur in domestic use, it is a wise precaution to use only canned fruits or pulp in confectionery or to boil fresh fruit syrups to destroy these enzymes.

Gelatin Jelly (Acid Jelly)

Sugar	25 lb
Glucose syrup (42 DE)	18 lb
Water	10 lb

Dissolve sugar in water, add glucose syrup, and boil to 115°C (239°F).

Gelatin	3.2 lb
Water	3.2 lb

Soak, warm to dissolve. Cool the above syrup to below 80°C (176°F), and then add the gelatin solution and mix.

Immediately before casting, add
 Citric acid 8 oz dissolved in
 Water 8 oz
 Essential oil of orange 18 ml
 (or other)

Orange color as required

Cast in dry starch impressions; allow to set for 12 hr. Remove by sieving. The jellies may be sugar sanded or chocolate covered.

Cast in dry starch impressions; allow to set for 12 hr. Remove by sieving. The jellies may be sugar sanded or chocolate covered.

Cast in dry starch impressions; allow to set for 12 hr. Remove by sieving. The jellies may be sugar sanded or chocolate covered.

Agar Jellies Agar-agar is a word derived from an Eastern expression meaning seaweed, and commercially the product is now shortened to "agar." (See "Gelatinizing Agents.")

It is a useful substance for the production of confectionery jellies. These tend to be short in texture and find particular use in the preparation of fruit slices, shaped, colored, and flavored to resemble sections of oranges, lemons, or grapefruit.

Agar was originally available only in strips, somewhat resembling dried seaweed, but the powdered product is now mostly used. It is not soluble in cold water but swells slightly on soaking. To dissolve, a large volume of water at boiling temperature is required, usually thirty or forty parts of water to one of agar. Agar is not destroyed by boiling water unless acid is present, when it is rapidly degraded. Therefore, any acid added must be after the syrup boil is completed.

It is advisable to add a buffer salt, such as sodium citrate, to offset the action of acid addition.

Agar jellies may be subject to syneresis and a general improvement in texture and shelf life may be obtained by combination with other gelatinizing agents, particularly pectin and starch.

Preparation of Agar Jellies, Fruit Slices

Jelly	25 lb
Sugar	20 lb
Glucose syrup (42 DE)	1 lb
Agar	40 lb
Water	5 oz
Sodium citrate	

Soak the agar in the water for 2 to 4 h, and then add the citrate. Bring to a boil and keep at this temperature for 5 to 10 min (simmer).

until the agar is in solution. Fibrous material is usually present, especially in the strip agar, so it is necessary to pass the solution through a fine sieve.

Add the sugar and, when dissolved, the glucose. Boil to 107°C (225°F). Pour into another pan to cool to 75°C (167°F) and remove any scum. Mix in

Citric acid	3 oz dissolved in 3 oz water
Essential oil, orange or lemon	20 ml
Color	as required

Cast without delay into dry starch (6 to 8 percent moisture). Do not hold the hot mixture for a long period after acid addition. The jellies should remain in starch overnight in a dry, warm room.

Small jelly pieces may be made in this way, or for fruit slices, the liquid mixture is deposited into semicylindrical impressions. These, when set, are removed, cut into slices, moistened, rolled in caster sugar, and dried.

To imitate the outer "rind" of the fruit slices, a paste may be prepared of the following composition

Glucose syrup (42 DE)	8 lb
Gelatin	4 oz
Icing sugar	12 lb
Cornstarch	1½ lb
Citric acid	1 oz dissolved in 1 oz water

The gelatin must be soaked and dissolved in 12 oz of water and then mixed into the heated glucose. After cooling, add citric acid. Mix the icing sugar and cornstarch dry, and then add the syrup gradually, kneading the mixture continuously.

At this stage, color and flavor can be added as required. The paste should now have a consistency such that it can be rolled into thin sheets. These sheets may be cut and applied to the round surface of the pieces after removal from the starch and cleaning. The coated jelly may then be sliced, moistened, icing sugar applied, and dried.

Special Note on the Preparation of Jellies When jelly mixes containing the gelatinizing agent are boiled (e.g., starch, agar, pectin), thermometer readings to determine the end point are unreliable. A refractometer should be used and the concentration of the syrup phase of the final product should always be greater than 75 percent.

MARZIPAN, ALMOND AND OTHER NUT PASTES

A great deal of argument has arisen from time to time regarding the definition of marzipan. Dictionary descriptions say that it is a paste composed of crushed almonds and sugar, but because of the high price of almonds, many substitutes have appeared on the market. These have been prepared from apricot kernels, soya flour, and various other ingredients, and are often much overflavored with synthetic almond essence.

Composition standards are, however, recognized in some countries and a distinction is also made between "raw marzipan" or "base almond paste" and the finished article, which is called "marzipan" or "almond paste."

A recognized formulation in the United Kingdom at one time for raw marzipan was a mixture of two parts of almonds to one of sugar. According to Jackson (1973), the United Kingdom "agreed" standard for marzipan is one part of ground almonds to three parts of sugar.

There are also the legal compositions quoted in the *Silesia Manual* (Vol. 2, No. 3, 1984), which are as follows:

1. *Raw Marzipan, Base Almond Paste.* Is a mass produced from blanched almonds, containing a maximum of 17 percent moisture and 35 percent sugar, and 10 percent of the whole mass may be invert sugar. Almond oil content minimum 28 percent. May contain up to 12 percent of the almonds as blanched bitter almonds. "Debittered" bitter almonds not permitted.
2. *Marzipan, Almond Paste.* Is a mixture of raw marzipan plus not more than an equal amount of sugar. The sugar may be partly replaced by glucose syrup and/or sorbitol. Up to 3.5 percent of the total weight of the marzipan may be glucose syrup and/or up to 5 percent of 70 percent sorbitol solution.

It is debatable whether much is achieved by all these complications. The public will decide whether it likes the product, and if not, will not buy it. That is just what has happened with the overflavored pastes mentioned previously.

Manufacture of Marzipan

Raw almonds are cleaned by sieving, air elutriation, and other electronic and mechanical devices. They are then immersed, usually in wire baskets, in water just below boiling point for about 5 min. This loosens the skins and the soaked nuts are then put through a

blanching machine consisting of rotating rubber rollers that squeeze the skins from the kernels. There are also continuous blanching machines.

The blanched almonds are then washed with cold water and inspected on a conveyor, where any residual skins, foreign matter, or defective nuts are removed.

From this stage different methods for paste manufacture may be used. Some manufacturers advocate drying the almonds, which, they claim, gives a better flavor—possibly it has the effect of a light roast, but slight loss of color results from this.

Whether they are dried or not, the next part of the process is to coarsely grind the almonds, and this is done by passing them through kibbling rolls or other grinding machine and then through a triple roll refiner.

This refined paste is mixed with sugar and a small proportion of glucose or invert sugar, and then transferred to a paster, which is usually a heated kneader. This gives the mixture a further cooking and reduces the moisture content.

After cooking, the paste is spread on tables to cool. This base is often refined again before making into bars and softened by the addition of invert sugar.

Another method for the preparation of almond paste consists of placing the refined blanched almonds in a trough mixer and pouring into this a syrup consisting of sugar and glucose syrup boiled to 250°F (121°C). Fondant creme is then added and mixing continued until the creme is fully dispersed, when the mixture is cooled and again passed through a refiner.

A typical recipe for this second process is:

Sugar	22.6 kg (50 lb)	
Glucose syrup	6.35 kg (14 lb)	Boiled to 250°F (121°C)
Water	9.1 kg (20 lb)	
Ground almonds	15.9 kg (35 lb)	
Fondant creme	6.8 kg (15 lb)	
(3 sugar 1 glucose syrup)		

The Stephan Method

The Stephan machine is useful for making marzipan and other nut pastes. Its action is such that it will comminute fibrous materials not readily handled by other refining methods.

The basic machine consists of a bowl with an internal rotating cutter that operates at speeds between 1,500 and 3,000 rpm. The bowl can be heated, cooled, and provided with steam injection. It can withstand pressure and vacuum. Raw materials may be fed directly into the machine and are then

subjected to pulverizing, mixing, and sterilizing. In the case of marzipan, blanched almonds, sugar, glucose syrup, and any of the other ingredients, such as invert sugar and sorbitol, are charged into the bowl. In a short time, the mixture is pulverized, mixed, and sterilized. Marzipan made this way has a soft texture.

Various models are available and a popular machine is the series UM/MC: see Fig. 19.33.

Shelf Life of Marzipan and Nut Pastes

Much has been written about fermentation in marzipan and many are the proposals to prevent it, including the addition of glycerol, acetic acid and bitter almonds. None of these additions is essential if the fundamental principles of confectionery technology are observed.

The first concerns the elimination of microorganisms in the raw material combined with good plant hygiene. The second is to make sure that the sugar/glucose/invert sugar ratios are correct, which, in conjunction with the moisture in the recipe, maintains a syrup phase concentration of 75 percent minimum after maturing.

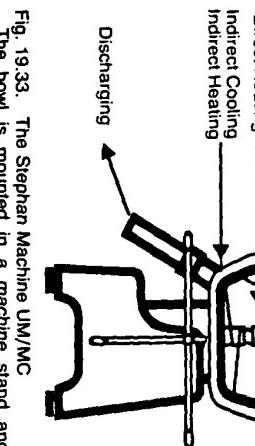


Fig. 19.33. The Stephan Machine UM/MC
The bowl is mounted in a machine stand and counterbalanced with its geared-down motor, making it easy to tilt. Once tilted, it can be locked at any angle in the range.
Bowl, lid, motor shaft, and all processing tools are made of stainless steel. The motor shaft extends into the bowl and carries the processing insert with its sturdy cutter blades (or the mixing and kneading insert). Bowl and lid are interlocked by means of accident-proof quick-release clamps.
The dosing of liquid and fluid raw materials can be carried out via the dosing valves without opening the lid and discharge is effected via a bowl outlet valve. As with all other functions, both of these valves are controlled from the separate switch cabinet.

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Nuts in the natural state contain microorganisms, including osmophilic yeasts as well as active enzymes. Unless destroyed, these will cause slow fermentation and off-flavors in the confectionery prepared from them. These organisms are resistant to destruction by heat in high sugar concentration media unless subjected to temperatures of 93 to 100°C (200 to 212°F) for 10 to 20 min. It is better to destroy these organisms during the blanching process by immersion in boiling water just long enough to ensure sterility. Three minutes should be long enough if the water surges through the nuts. Some manufacturers claim that blanching for longer than an instantaneous immersion is detrimental to flavor but this is doubtful.

Plant hygiene has been mentioned in many processes. With marzipan manufacture utensils used for raw nuts must never be used for finished products unless cleaned and sterilized. Dusts from nut cleaning are particularly dangerous and this operation should be done away from the paste department. Marzipan scrap should be sterilized by heating if it is more than 24 hr old.

The practice of covering pastes and fondant with wet cloths to prevent drying out is entirely wrong and unfortunately is still recommended in some textbooks. The same applies to wet cloths used for hand wiping, and bacterial examination of specimens found occasionally in the factory have revealed a very high population of microorganisms.

Concerning the soluble solids concentration, base marzipan consisting of almonds and sugar alone cannot attain a concentration higher than 67 percent because this is the maximum solubility of sucrose and the soluble part of the nut contributes very little. Therefore, if this is made, it should be kept for the minimum time. A better procedure is to use the sugar/glucose/invert mixtures as the ingredients of the syrup base with a minimum of 20 percent glucose syrup. This will give a satisfactory syrup concentration when the moisture content of the marzipan is 8 percent. A check can be made by extracting some of the syrup phase from matured paste by means of a "syrup press" (Fig. 19.34) and determining the concentration by refractometer.

Since the inhibiting action of certain chemical substances has been mentioned, some idea of the quantities required should be given.

The introduction of an organic acid is effective if, for any reason, low soluble solids have to be tolerated. Acetic acid seems the best, but at the really effective levels of 0.1 to 0.2 percent an objectionable flavor is detectable. Even at the minimum of 0.05 percent some

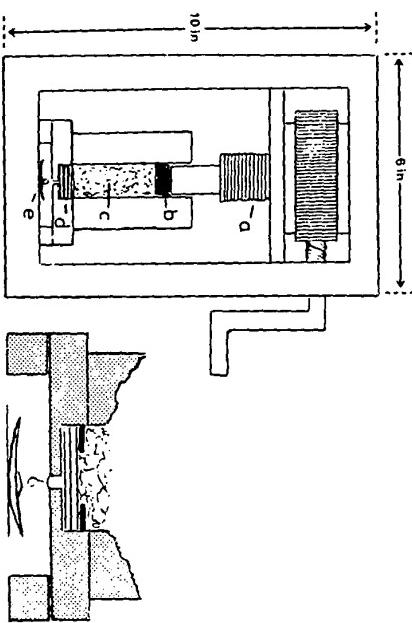


Fig. 19.34. Diagram of Syrup Press
a. Gear and Ram
b. Leather Washer
c. Fondant or Marzipan
d. Section of filter (d), (e) showing upper fiber washer, upper wire gauze, filter paper, lower wire gauze. Beneath the lower gauze are grooves leading to the central orifice (approx. dimensions shown).

people can taste the acid. Lactic acid is less effective and at higher levels the taste is not so easily detected. Glycerol and sorbitol syrup have an inhibiting effect and will help to keep the paste soft and retard crystallization, usually 2 to 4 percent is used in the recipe. Bitter almonds have also been shown to inhibit fermentation, possibly due to the glucoside amygdalin, and 2 to 3 percent of bitter almonds are often added to almond paste to enhance flavor and these help with preservation.

Sorbic acid where permitted, is an effective preservative used at the rate of 0.1 to 0.2 percent.

Persipan

This is an "official" name for a paste made from debittered apricot or peach kernels. Correctly made, it bears a very close resemblance to the true almond paste.

There are two methods of debittering. One is to subject the kernels to washing with cold water until the bitter glucoside (amygdalin) is removed. This is wasteful as other useful soluble solids are lost. The second method is to make use of the natural enzyme, emulsin in the outer layers of the kernel. This will decompose the amygdalin into hydrogen cyanide, benzaldehyde, D-glucose. The kernels are chopped finely and water added until a slightly wet mash is obtained, and this is incubated at 30°C (86°F) for 24 hr. Ventilation and extraction must be provided to remove the hydrogen cyanide evolved. If the kernels have been blanched by a scalding process, emulsin enzyme must be added to bring about the reaction. The only loss in this process is the cyanide, and the wet nuts can be used direct to make the persipan.

The preparation of persipan from the debittered kernels is the same as for marzipan.

COCONUT PASTE, COCONUT ICE

Coconut is a very popular ingredient in confectionery. Coconut ice is one of the traditional sweets made at home.

The main ingredient of most coconut lines is desiccated coconut, although some confectioners claim that only fresh coconut gives the true flavor and a juicy tender texture. Coconut is also available in other forms, such as sweetened desiccated, tenderized, and canned in syrup.

Desiccated coconut, being prepared from a natural product, may contain microorganisms. Unfortunately, it has had some reputation in the past for being responsible for outbreaks of salmonella poisoning and typhoid, due to unhygienic methods of preparation in some parts of the world. Unsatisfactory drying procedures also have caused the presence of lipase, resulting in soapy rancidity developing in the final confections.

Because of these dangers, methods of sterilization of all supplies were introduced and at the same time delegations from user countries advised on improved methods of processing in the growing areas. The production of desiccated coconut is described in the chapter on "Nuts," and today supplies are of much higher quality.

Coconut Ice

Coconut ice was originally prepared from boiled sugar syrup to which coconut was added together with some color and flavor, the sugar being allowed to crystallize with the coconut as a result of stirring.

This home-made sweet had a relatively short shelf life—it dried out, developed a coarse grain, and sometimes fermented because, with sugar alone, the minimum syrup phase concentration of 75 percent could not be obtained.

Modern recipes contain glucose and often condensed milk, honey, gelatin, and various flavors. Texture varies from soft pastes granined off with fondant creme to semihard caramel-like Japanese desserts. Some typical recipes are given below:

Coconut Paste

Sugar	4.53 kg (10 lb)
Glucose syrup	1.36 kg (3 lb)
Water	1.81 kg (4 lb)

Sweetened condensed milk

Fondant creme (80/20)	0.68 kg (1½ lb)
Fine desiccated coconut	1.80 kg (4 lb)

Add the condensed milk to the hot syrup and mix well. Then stir in the desiccated coconut and follow this with the fondant creme, which should assist the crystallization of some of the sugar in the syrup.

Flavor and color can be added as required. Texture may also be adjusted by the addition of a small amount of honey or invert sugar.

The paste is cooled on a table, rolled, and cut into bars, or it may be extruded. This type of paste has the best texture when the moisture content is 11 to 12 percent and the coconut then appears less tough and fibrous. Adjustment of moisture content can be obtained by altering the syrup's boiling temperature or by adding invert sugar. By using sweetened condensed milk, some milk fat will be included, which may affect shelf life. Nonfat milk is preferable.

Japanese Dessert

Sugar	2.26 kg (5 lb)]	Dissolve and boil to
Glucose syrup	3.17 kg (7 lb)]	115°C (240°F).
Water	0.68 kg (1½ lb)]	

Fine dessiccated coconut

2.7 kg (6 lb)

Stir the coconut into the hot syrup and add flavors as desired. Dried or preserved fruit pieces may be added to improve the character of this sweet. It is cooked on a table, rolled and cut.

Tenderizing Coconut

In many coconut confections, the coconut exhibits a fibrous texture and may leave a somewhat objectionable residue in the mouth. It is claimed that the use of fresh coconut will avoid this. Thus is generally not a practical proposition for most manufacturers, who normally use desiccated coconut.

As mentioned previously, processed coconut in cans, or sweetened and tenderized, is available and the confectioner must judge for himself whether the extra cost of these is justifiable.

Various methods for tenderizing desiccated coconut have been proposed. These include soaking in hot invert syrup with or without a proportion of sorbitol.

Important factors to recognize are the moisture content and syrup phase concentration of the final confection and the proportion of syrup to nut.

High syrup concentrations have a toughening effect on the nut fiber. A moisture content of about 11 percent with a syrup phase concentration of 76 to 78 percent is optimum.

CREME AND LOZENGE PASTES, CACHOUS, TABLETS

Lozenges, Cachous

Lozenge pastes are used a great deal for the manufacture of medicated sweets, cachous, and the like. They are relatively simple recipes consisting of icing sugar kneaded into a paste with a gum mucilage, gelatin solution, or both, and then rolled, shaped, and cut, followed by drying.

Since these are made from gum solutions and sugar only, the formulation of the mucilage is important. Gum arabic, gum tragacanth, and gelatin are used.

For machine-made lozenges, some manufacturers say that mucilages prepared from a mixture of gum tragacanth and gelatin are more easily managed than gum arabic solution, which is reserved for hand-made recipes.

The following is a typical formula for mucilage:

1. Gum arabic	1.81 kg (4 lb)
Water (cold)	4.1 kg (9 lb)

Soak with occasional slow stirring for 24 hr. Sieve through a fine mesh to remove foreign matter.

2. Gum tragacanth	141 g (5 oz)	Soak first using 5 lb of water for 6 hr and then add the remainder of the water and soak for a further 18 hr.
Water (cold)	3.17 kg (7 lb)	

Gelatin	198 g (7 oz)	Soak until the gelatin is soft, then warm to dissolve, and cool.
Water (cold)	2.26 kg (5 lb)	

The mucilage consists of a mixture of equal amounts of these solutions. The gum solutions must be used fresh as they will deteriorate on keeping, due to bacterial action, and they must be used cold.

The mucilage is mixed with powdered sugar to give the required texture, flavor and color being added as necessary.

With larger-scale batches, a "Z"-arm kneader is used. Judgment of the texture of the mixed paste is visual unless the particle size distribution of the sugar can be guaranteed. The condition of the sugar dough must be correct for the stamping machinery to give good shapes without sticking or collapse of the pieces.

After forming, the pieces must be dried slowly, first with slightly warm air, 24°C (75°F), preferably humidity controlled at about 50 percent relative humidity. This can be done on wide, moving belts. The lozenges are turned over automatically by transfer from one belt to another, and this process may take up to 4 hr to ensure even drying.

The lozenges are then sufficiently firm for drying in a stove or hot room, which is usually done in trays. Stoving is at 38°C (100°F) for 24 hr.

Flavor The procedure of drying is responsible for the loss of flavor in some formulations. Some flavors are particularly volatile, peppermint, for example.

Loss of flavor can be reduced by a premix with fine sugar or cornstarch or by the use of encapsulated flavors.

Creme Pastes

Creme pastes are made in a manner similar to lozenges but with the inclusion of glucose syrup to give a softer finished product. The following is a representative formula and process.

Fine sugar (icing, caster or mixed)	4.53 kg (10 lb)
Glucose syrup	1.58 kg (3½ lb)
Gelatin	56.7 g (2 oz)

The gelatin is soaked until soft and then mixed into the glucose syrup, which has been warmed until fluid. A little water may be added to increase fluidity. The sugar is placed in a mixer, usually of the trough type with horizontal spindle and carrying paddles, and while in motion the glucose/gelatin syrup is added slowly until a fairly stiff paste is produced. This is flavored, colored, rolled, and shaped and the finished pieces are allowed to dry and set.

Lozenges and pastes have many applications in the confectionery and pharmaceutical industries. The formulation is simple but the production needs care and understanding of the kneading and drying processes. Incorrectly prepared paste will not form correctly; it will stick to the cutters or deform after cutting. Uneven drying will also give poor shapes and uneven texture.

Tablets

Compressed tablets are mixtures of base materials, binders, flavors, and a lubricant. The base material may be icing sugar, dextrose, or lactose. The binder is gelatin or gum arabic. Lubricants are necessary to give good release from the press and consist of magnesium and calcium stearate or stearic acid. Flavors and colors must be powders.

Special machinery is used for tablet making and consists of compression punches that close over the mixture of ingredients. These ingredients are in a granulated form produced either by wet granulation or "slugging."

In wet granulation, the mixture of ingredients is wetted to a dough, granulated, sieved, and dried. This dry material is flavored, and colored, and the lubricant added in a separate mixer. It is then ready for feeding to the tablet press.

Slugging is used when the tablet mixture consists of substances of a hygroscopic nature or is volatile (e.g., some flavors and medicaments).

The slugs are prepared from the mixed powders in a tablet machine of large bore, which produces pellets suitable for breaking and granulating. They do not need drying and can be fed directly to the tablet press.

Compressed tablets are particularly popular for sweets sold in roll or stick packs. Mint-flavored tablets are very well known.

Compressed tablets containing dextrose give a cooling sensation in the mouth. Sugarless tablets have been sold in large quantities in the United States and consist of powdered sorbitol and flavor, usually mint. Sorbitol is of a plastic nature and will consolidate under pressure without a binder.

Effervescent tablets are possible. Icing sugar, sodium bicarbonate, color, and mucilage are first mixed, granulated, and dried. Citric acid is then added in a tumbler mixer, with dry flavor and lubricant. This is fed to the tablet press.

Jackson (1973) describes tabletting in considerable detail and specialists in tabletting machinery will provide information.

As with all confectionery products, many formulations exist. As an example, the following describes a compressed peppermint tablet:

Icing sugar (free flowing)	50 lb
Peppermint oil	5 oz
	(up to twice this amount for very strong mint)

Powdered gum arabic	1 lb
Water	up to 3 lb

Magnesium stearate (or stearic acid)	8 oz
--------------------------------------	------

Mix the powdered sugar and gum arabic thoroughly. Add water sufficient to make granules. Dry the granules at about 60°C (140°F). Mix in the peppermint oil and lubricant and subject this to tabletting. The compressed tablets should be dried at a low temperature, 38°C (100°F).

LIQUEURS

There are several types of liqueur chocolates.

Chocolate Liqueurs

Chocolate shells are preformed and the alcoholic liqueur is deposited into the shells. For this type, the shells are usually bottle shaped.

Another type of chocolate shell, used for assortments, resembles the shape of an enrobed chocolate. The "liqueur," not necessarily alcoholic, is deposited into the shell, followed by spraying with cocoa butter and backing with chocolate (see "Chocolate Shells").

Sugar Crust Liqueurs

This liqueur piece consists of a crystalline sugar shell containing a liquid center and is chocolate covered. The liqueur in the center may be alcoholic or merely a flavored syrup.

The principle of preparation, whether or not alcohol is involved, is to deposit the syrup mixture into starch impressions at a concentration that will form a crystal layer at the surface in contact with the starch.

The interior must remain liquid. Crystal formation is aided by the cooling and slight loss of moisture to the starch, which should have a moisture content of 5 to 7 percent and a temperature of about 30°C (85°F). After depositing is completed, a starch layer is dusted over the surface. The syrup remains in the starch for 2½ to 3 hr during which time crystallization occurs, mostly on the lower surface.

At this stage, the semicrystallized pieces are turned over. This requires skill and the operation involves passing a shaped wire through the starch and beneath the crusted shapes.

In the process of manufacture, great care must be taken to avoid unwanted or poor crystallization. High-grade sugar must be used and vibration avoided at all stages.

The following are typical formulations. They all need practice before good results are obtained.

Sugar Crust Liqueurs with Alcohol

Sugar, high grade 100 lb

Water 40 lb

Cook to 113°C (236°F). Cool to 70°C (158°F). Add the following alternative liqueurs by very careful pouring them, in a thin stream, into the syrup at a temperature between 60 and 70°C:

1. Proprietary liqueur, 60 percent alcohol, 25 lb
2. Rectified spirit, 96 percent alcohol, 15.6 lb

Water, 9.4 lb

Flavor as required.

3. With red wine, 12 to 14 percent alcohol

Cook syrup above to 118°C (245°F)

4. "red wine," 28.5 lb } warm to dissolve.

Add Fine sugar, 8.5 lb }

Then deposit in starch [5 to 7 percent moisture, 30°C (85°F)].

Sugar Crust Liqueurs Without Alcohol

Sugar, high grade 100 lb } Cook to 110°C (230°F).

Water 40 lb

Cool to 60°C (140°F).

Add citric acid 0.5 lb (in 0.5 lb water)

Flavor as required

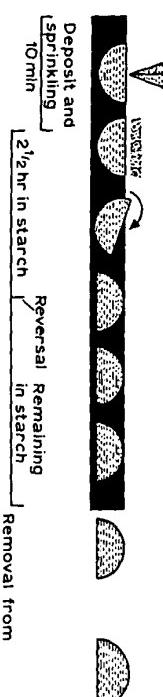


Fig. 19.35. Sugar Crust Liqueurs without Alcohol

TABLE 19.5. PERCENT SOLUTION BY WEIGHT IN ALCOHOL IN

°C	0	6	12	20
20	66.9	61.0	55.1	47.4
40	70.6	65.2	59.6	52.0
55	73.7	68.6	63.2	55.5
70	77.1	72.4	67.1	59.1

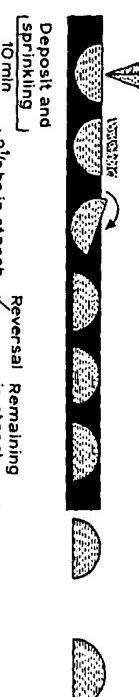


Fig. 19.36. Sugar Crust Liqueurs with Alcohol

Central College of Confectionery, Solingen, Germany

Deposit in starch at this temperature. Figures 19.35 and 19.36 illustrate the sequence of operations. In the preparation of sugar crust liqueurs with alcohol, two factors must be realized:

1. Sugar solubility is depressed by the presence of alcohol as is shown in Table 19.5.
2. Alcohol and water contract in volume on mixing, as shown in Table 19.6.

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Complete tables are available in handbooks of physics and chemistry. Jackson (1973) gives further information on the preparation of liqueurs.

PANWORK, DRAGEES—HARD AND SOFT PANNING

"Dragees" is the name given to sugar-coated confectionery where the sugar has been applied as successive layers of syrup in a rotating pan. Reference has already been made to panning under "Chocolate Processes" where a similar procedure is used to coat nuts and other confectionery pieces with chocolate.

There are basically two types of sugar panning:

1. Hard Panning

- (a) Hard texture, smooth, round or ovate, opaque appearance.
- (b) Pearl—hard with a rough surface, opaque.

With hard panning, successive layers of syrup mixture are applied. Each layer is dried by injection of warm air into the pan. Pans may be provided with heating coils attached to the exterior of the pans or, in some instances, the pan is heated while rotating by means of gas flames beneath the pans.

Traditionally, all pans were made of copper but stainless steel is gradually replacing copper. Pans are of various sizes and shapes and the speed of rotation and angle of tilt can be varied.

A basic requirement in all panning processes is to ensure that the articles in the pan are rolling and not sliding. This is usually achieved by careful intermittent addition of the syrup and powdered sugar.

Occasionally, ribs may be attached to the interior surface of the pan. Often a roughened layer of confection is built up on the inside of the pan to encourage rolling.

If the pieces in the pan slide and the syrup mixture is applied erratically, bad shapes occur and the articles will conglomerate.

2. Soft Panning

Soft confectionery centers, (e.g., coconut pastes, soft caramels) are coated in successive layers of sugar/glucose syrup. They are "dried" by application of fine sugar without air blowing. Smaller pans and higher speeds are usual for soft panning.

Examples of various panning processes are given below but it must

be realized that this is a confectionery operation that is probably subject to more variations and personal opinions than any other.

The panning process with all its ramifications is a highly skilled operation when a variety of products is being manufactured with a small number of pans. Addition of the syrups and powders and application of the air to the pan becomes a matter of judgment and experience.

On the other hand, when large quantities of the same kind of product are being made, the process can be mechanized and standardized. A description of mass production machinery is given later.

Sugared Almonds

With nuts it is advisable to preglaze by coating the nuts with a gum arabic solution or gum/syrup mixture.

Gum arabic	0.90 kg (2 lb)
Water	1.36 kg (3 lb)

Dissolve and sieve as described in previous recipes.

The almonds, which have been previously dried or lightly roasted, are placed in a revolving pan and the gum solution applied in small quantities so that thin layers are distributed evenly over the surface of the nuts and any wrinkles filled. The pan and gum solution are cold but slightly warmed dry air may be directed into the pan. Fine sugar is sifted over the rotating nuts, which helps to dry the gum film and to separate the nuts. More gum is applied followed by sugar until an even coating is obtained when the nuts are discharged into wire mesh trays and dried in a warm room (29°C/85°F) for 24 hr.

It is also possible to dry using the air blown into the pan if time is available.

The nuts are then subjected to the "engrossing" process and sugar/gum syrup is required for this:

Sugar	4.53 kg (10 lb)
Water	2.04 kg (4½ lb)

Dissolve by boiling and adjust the concentration to 67 percent determined by refractometer or hydrometer. Then add 12 oz of gum solution as used for the almond coating and mix well.

The almonds with the gum/sugar coating are placed in the rotating pan with slight heat applied and a small amount of gum syrup added to give a continuous thin layer over the surface. As the layer

approaches dryness, icing sugar is dusted on, followed by further applications of gum/syrup. The nuts rotating in the pan will gradually enlarge with each application of gum syrup and icing sugar and this is continued until the correct unit weight is obtained. During the last stages of building up, color may be added to the syrup, and to obtain opacity and bright colors or pure white the addition of some titanium dioxide (Pure-food grade) is permissible.

Lake colors are preferable for coloring as they are insoluble. Soluble colors may be used but these are prone to cause staining in the mouth.

After coloring, a finishing glaze is applied, which consists of a sugar syrup of 60 percent concentration.

In some panning operations, cornstarch is used for building up as well as fine sugar. This is cheaper, but uncooked starch in quantity gives a mealy texture and is not readily digested.

Roast almonds, hazelnuts, and peanuts can be coated by the method just described and flavors can be added during the building-up process.

A very popular product is made from small chocolate pellets as the center. These are made on a Roller depositing machine and they are coated with a thin sugar layer, multicolored, and polished. They are essentially a children's line.

Nonpareils, Comfits, Aniseed Balls

These are much smaller panned articles but the process of manufacture is very similar and needs only adjustment of the syrup strengths to suit the size and allow the pieces to tumble over one another. Syrups of the following concentration may be used:

First coating foundation	40 to 45 percent
Building up	65 percent
Finishing	50 to 55 percent

For nonpareils, free-flowing, fairly coarse crystal granulated sugar is used. It is sifted free from dust and the coarse grain charged into a warm pan. Fifty percent syrup is poured on until well distributed over the grains, a process that must be assisted by running the hands through the mass. Small amounts of cornstarch are used to promote free flowing and the addition of syrup is continued alternately with cornstarch until sugar grains have built up to the required size. Coloring and flavoring are added in the final syrup additions. Seeds of caraway, coriander, and aniseed are processed as nonpar-

eils, the original seeds being well dried and sifted free from dust before panning commences.

Pearling

This is a process of sugar panning where syrup with a small addition of gum arabic is allowed to drip in a controlled flow over the confectionery revolving in a pan until the required size is obtained. The centers may consist of pieces of candied peel or other fruits, dried fruits, angelica, sugar boilings, or pastes. Before pearling they are coated with gum solution and dusting sugar as described previously.

Polishing Sugar-Panned Products

The gloss obtained by the above process can be enhanced by wax glazing, using beeswax, carnauba wax, or spermaceti. The best way to apply this is to coat the interior of a pan by pouring in sufficient molten wax to cover it completely with a thin layer. The surface must be quite smooth and this is attained by polishing with a fiber-free cloth, preferably coated in talc. The use of talc, however, is not permitted in some countries.

The units to be polished must roll and not slide in the pan and an oscillating pan is better for this part of the process. Cool air should be applied to the pan as frictional heat will cause the wax on the pan to become too soft.

Other proprietary materials are available for polishing. These consist of acetylated monoglycerides and are described under "Chemical and Allied substances" and "Glazes."

Soft-Centered Pan Work

A large variety of confectionery centers can be used for this process. Coconut and other pastes, jellies, marshmallows, Turkish delight, Japanese desserts, and caramels may be coated.

It is essentially a cold process in which the centers are rotated in a pan coated internally with a rough sugar layer. During normal sugar panning a layer of this nature is obtained.

The centers, which are usually pressed or cut into shapes, are charged into the pan and while rotating, glucose syrup solutions are applied alternately with caster sugar until the correct size is obtained. Syrup of a concentration of 60 to 65 percent is used but this may be varied according to the texture of the center. The final sugar

dustings are with icing sugar, which gives a smooth surface, and when this has been obtained, the units are discharged onto a tray and allowed to set in a dry, but not hot, atmosphere for 16 to 24 hr.

Glaze is then applied by the same process as for dragees.

Jelly beans, birds' eggs, and many candies attractive to children are prepared by this method and as with all soft confectionery great care must be taken to ensure that a minimum syrup phase concentration of 75 percent is obtained in the center.

The speckled appearance of birds' eggs may be obtained by subjecting the unglazed centers to a coarse spray of dye solution, which is allowed to dry before glazing. For small batches, a stiff brush with long bristles may be dipped in the solution and droplets flicked off by bending the bristles with a rod and releasing.

Sometimes soft panning is used as a preliminary to enrobing. Preserved ginger is an example; this tends to exude syrup and chocolate covering by enrobing is difficult in these circumstances.

The syrup may be absorbed by panning with the addition of sugar or cocoa powder, followed by a chocolate layer. The units are then suitable for enrobing.

When egg, gelatin, or milk products are used, the same care is needed in observing hygienic methods and to destroy microorganisms and lipolytic activity by pasteurization.

Silver Cachous

The manufacture of these needs skill and experience and the final sugar coating is carried out in a glass or glass lined pan.

The center is built up from granulated sugar graded by sifting, and the application of syrups as for nonpareils. Some gum arabic solution can be incorporated in the syrup and when the correct size of sphere is obtained with a smooth surface the silver coating is applied as follows:

Adhesive Solution

High-grade gelatin 226.8 g (8 oz)

Soak in water until soft, then dissolve in a warm mixture of

Glacial acetic acid 397 g (14 oz)

Water 795 g (28 oz)

Acetic acid has the effect of hardening the gelatin jelly. The cachou centers are placed in a separate bowl, some of the

gelatin solution added, and the pan oscillated and rotated to give a very thin film spread completely over the surface of the centers.

This operation is very important and the exact conditions and quantity of syrup can only be found by trial. Too much will cause the silver leaf to soak into the syrup and it will not spread out as a layer. Too little syrup will give patchy results where the silver leaf has not adhered properly.

Some of the leaf is placed in the glass pan and this is set in motion. The moistened cachous are added in a thin stream, generally through a funnel, and will pick up the silver leaf and gradually become completely coated. No heat is used. When coated, it is best to transfer them to a separate glass pan or bowl where they are rotated at high speed for polishing. When manufactured, the silver cachous must be transferred quickly to closed, preferably glass, containers to prevent them from tarnishing. When used on soft confections or cakes, they tend to have a short shelf life and lose their luster.

Silver leaf must be food grade, and foreign metals, particularly lead, must be absent.

Modern Machinery for Panning

In recent years, there has been a great deal of development in the mechanization of the panning process. The following methods are in use:

1. Mechanization of the standard rotating pan system. Here progress has been made by
 - a. Automatic filling and discharge of the pans by tilting.
 - b. Automatic control of the application of chocolate or syrups using spraying and air-drying techniques controlled by electronic programming and instrumental measurement of relative humidity within the pans.

By this automation one man may handle production from a number of pans but the system is more suitable for the manufacture of large quantities of the same line.
2. New principles
 - a. Redesign of the rotating "pan"—the cylindrical machine by Dumoulin is an example (Fig. 19.37). Another example is the Driacoater, which uses a perforated drum; the process is computer controlled.
 - b. Coating on a continuous belt. The principle is to do the coating in the loop of a continuous belt. Several machines have appeared and there are problems with this method.

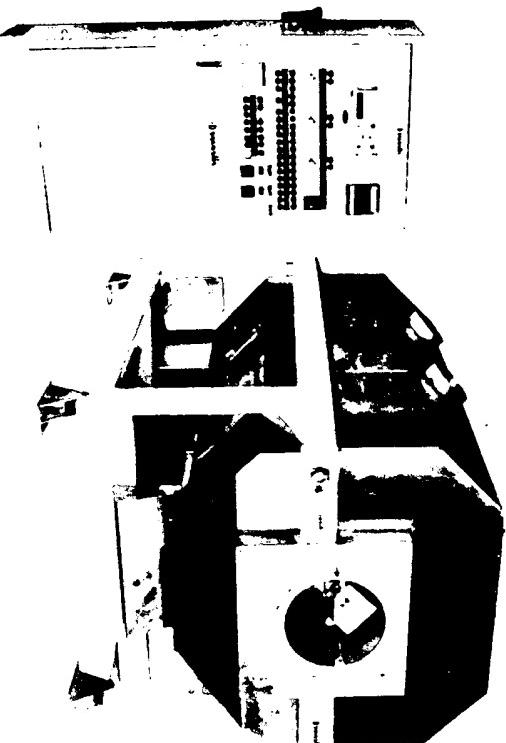


Fig. 19.37. Cylindrical Rotating Pan I.D.A.-X. The interior of the cylinder is provided with baffles to ensure tumbling of the product. Sprayers extend the length of the cylinder. Discharge is automatic. Controlled air drying with twin circuit air distribution.

Dumoulin et Cie, La Verenne, France

CRYSTALLIZATION OF FONDANTS AND OTHER CONFETIONS

Cremes and other centres that have been cast in starch will dry out under average ambient conditions unless they are given a protective coating. Normally, they would be covered with chocolate or a compound or pastel coating. These are fat based and retard the loss of moisture from the centre.

Protection will also be given by forming a sugar crystal layer over the surface. Formation of this layer by steaming and sanding has already been described under gums and pastilles.

This method is not suitable for cremes or pastes, such as marzipan. Wet crystallization is used in these circumstances and the process consists of growing a continuous sugar crystal layer over the surface

of the confections by immersion, in single layers, in a solution of sugar slightly supersaturated. This not only gives protection but greatly enhances the appearance, giving a sparkle to the surface.

The preparation of the syrup must be carefully done to avoid premature crystallization, and this means boiling quickly to dissolve all solid sugar, and to prevent inversion, cooling without movement, and filling the crystallizing bath or trays with as little disturbance as possible.

Vibration from machinery or other causes in the department must be absolutely avoided. The solubility of sugar at 20°C (68°F) is 67 percent and to promote controlled crystallization on the surface of fondants the syrup concentration should be just above this.

Preparation of Syrup

The highest quality white sugar is required to make the syrup:

Sugar	45.3 kg (100 lb)
Water	24.5 kg (54 lb)

The sugar is dissolved and heated rapidly to boiling, when any scum is removed and crystals adhering to the inside of the pan dissolved by washing down or steaming. Boiling is continued until a concentration (determined by refractometer) of 68 to 70 percent is reached. The higher the concentration, the coarser is the crystal layer. The layer is also formed more quickly but the appearance suffers and the layer may contain agglomerates of sugar.

When the correct concentration is reached, the hot syrup is passed through a fine sieve into a cylindrical pan and allowed to cool in the crystallizing room without disturbing. The pans are covered with lint-free cloth—not lids, which cause condensation and a weaker solution on the surface of the syrup.

Crystallizing

There are two methods of crystallizing—the tray and tank systems.

Tray Crystallizing Rectangular trays and wire mesh inserts are used; the trays have sloping sides and both the mesh and trays are heavily tin plated or are stainless steel. Dimensions are approximately 15 in. by 9 in.

The cremes are arranged on the wire mesh at the bottom of the tray.

The trays are placed on open racks in a room held at a constant temperature between 21°C and 22°C (70 to 72°F). The prepared syrup is poured over the fondants until they are covered to a depth of a $\frac{1}{4}$ to $\frac{1}{2}$ in.; a second wire mesh is then placed over the top of units. The trays of syrup and fondants are allowed to stand undisturbed for up to 16 hr depending on the thickness of crystal layer required.

At the end of the crystallizing period, the units should be coated with a continuous layer of crystal and the trays are then tilted to drain off the syrup from the corners. The tray racks are provided with slots to hold the trays in a sloping position and troughs to collect the syrup. When draining is complete, usually 4 to 5 hr, the trays are placed flat again, the top mesh removed, and left to dry for 16 to 24 hr. During the drying process, it is customary to tap each tray periodically to release any cremes adhering to the mesh, and it will also help to make the crystal layer more continuous over the surface in contact with the wire.

Tank Crystallizing The second method of crystallizing is more in keeping with modern methods of production and uses a tank system. The principle is to use a nest of wire baskets held in a large cage, the baskets being packed in single layers with the fondants to be crystallized. The cage is controlled by a hoist that enables it to be let down into a tank containing the crystallizing syrup. The syrup for the tank is prepared in a separate pan with the same meticulous care as described above and is fed through a fine sieve from the pan to the tank. After the crystallizing process, the cage of baskets is lifted out of the tank and allowed to drain and dry on a large tray adjacent to the tank. The crystallized fondants should be ready for removal after 24 hr but good air circulation is necessary.

The syrup from the tank and draining trays is discharged for reboiling or reclaiming. The crystallizing tank must be steamed out and no crystal residue whatever must remain or trouble with the next batch will arise.

The process of crystallizing can give endless trouble if methods are slipshod, and before leaving the subject, the following points should be emphasized:

Syrup This must be prepared with great care as described and must not be allowed to come in contact with any sugar crystals while cooling and must never be stirred or vibrated. It is best not to use the syrup more than once although there are manufacturers who reboil the syrup and add small amounts of

sodium citrate buffer salt to reduce inversion. The syrup should have a pH in the region of 6.0 (± 0.2) for best results and this gives good color retention and minimum inversion.

Repeated use gradually darkens the syrup, and where this has occurred, it can be used for crystallizing colored fondants or jellies. New syrup must be used for white fondants such as mints or other high-class pale-colored fondant.

By far the best procedure is to use freshly prepared syrup. The larger manufacturers usually have reclaiming equipment and very little cost is involved in disposing of spent crystallizing syrup with solutions of other confectionery scrap.

The Crystallizing Department Rarely is enough care taken with the construction of the crystallizing room and too often it is part of another confectionery department. This is false economy and results in poor work and a lot of waste. The essential points are:

1. The room must be free from vibration.
 2. The syrup boiling section must have good extraction ducts to remove steam and preferably be partitioned from the crystallizing room.
 3. The crystallizing room must have an even temperature of between 21 and 22°C (70 and 72°F) and it is preferable to have it thermostatically controlled. High humidities are most undesirable and a range of 50 to 60 percent should be maintained.
- Cleanliness** Without clean working success will never be achieved. All tanks, trays, or utensils used for crystallizing or for containing the new syrup must be absolutely free of sugar residues. Dust from starch rooms or elsewhere must not settle on the crystallizing syrup or equipment.

LICORICE

Licorice confections are very popular, particularly the "Allsorts" type where licorice pastes are sandwiched with other confectionery pastes. Many other products make use of the medicinal properties of licorice, as in throat lozenges and gums and for aperients.

The licorice plant, botanically, is Glycyrrhiza and there are many species, Glycyrrhiza glabra being the most well known. It grows wild in the subtropical areas of Europe and Asia and is a leguminous weed. The root will, in favorable circumstances, extend to 25 ft below ground and varies in thickness from thin fibers to several inches in diameter.

It is mostly harvested in the autumn by peasant populations by the process of hand digging, and delivered to central collecting stations and dried to about 10 percent moisture.

Licorice is unique as it is the only known plant that contains considerable quantities of the glycoside called glycyrrhizin, which varies from 6 to 14 percent according to the origin of the root. This is the sweetest chemical substance found in nature, being about fifty times as sweet as sugar.

All licorice products are prepared from an extract of the root and this is made by grinding the root, leaching with hot water, and evaporating the solution. Modern processes use counter current extraction methods and multiple-effect evaporators for maximum economy. The concentrated extract is then dried to produce block or granulated licorice.

Spray-dried licorice powder is also available. It is free flowing with a moisture content of 3 to 5 percent. It is easier to dissolve than block juice that requires breaking and soaking.

A typical composition of block licorice is, in percent:

Moisture	18
Glycyrrhizin	18
Natural sugars	11
Gums, starch	28
Color and other extracts	20
Ash	5

A licorice derivative known as ammoniated glycyrrhizin is finding application as a special sweetener in baking and confectionery products. It is stated to enhance cocoa and chocolate flavors and has the following approximate composition, in percent:

Moisture	10
Glycyrrhizin	81
Natural sugars	trace
Gums, starch	1
Ash	0.5
Other extracts	7.5

Manufacture of Licorice Confectionery

Ingredients The important ingredients of licorice paste are:

1. Licorice block juice (or other prepared licorice as mentioned previously).

2. Flour—preferably a strong wheat flour.
3. Brown sugar—the various brown grades described under confectionery ingredients are all suitable. Molasses, treacle, and golden syrup may also be included.
4. Glucose syrup. High DE glucose is preferable or dextrose hydrate may be used.
5. Gelatin. This gives body to the final product and acts as a binder. A medium-grade gelatin is satisfactory and no advantage is obtained by using high-grade, light-colored material.
6. Color. Caramel color is generally used in addition to food-grade black dye, as it softens the intensity of the dye and imparts luster to the product.
7. Emulsifier. Glycerol monostearate is usually added to prevent the licorice from sticking to the teeth. About 0.1 percent is adequate and sometimes 2 to 3 percent of fat (hardened palm kernel oil) is emulsified into the mix. This acts as lubricant and will aid extrusion.
8. Flavor. Aniseed oil is regarded as the flavor for licorice.

Manufacture The fundamental part of the process is to gelatinize completely the starch in the flour ingredient—this applies to all confectionery—but in licorice bad dispersion and cooking will show as white flecks or lumps in the end product.

Recipes Published recipes for licorice pastes vary considerably, some are deficient in licorice content and overburdened with starchy material. Those shown in Table 14.7 are typical of the proportions of various ingredients used.

TABLE 14.7. LICORICE—PROPORTIONS OF INGREDIENTS

	Normal range, %	Published recipes, parts by weight		
		1	2	3
Flour	30-40	24	12	30
Sugar (various types)	50-60	16	6	22
Glucose (corn syrup)		8	3	—
Treacle		—	—	14
Caramel	6-25	12	6	3
Block licorice juice	3-6	4	2	2
Gelatin (150 Bloom)	0.5-4	8	2	1
Residual moisture	17-18	30	18	30
Water				

Process

Licorice Base for "Allsorts" and Similar Products as Recipe 1 The gelatin is soaked overnight in some of the water. The sugar, glucose, and block licorice are dissolved in the remainder of the water by heating. This solution should be sieved and cooled to about 37.7°C (100°F) and the soaked gelatin and the flour added, a portion at a time, so that a smooth slurry is obtained.

Cooking is then commenced and continued with stirring until the flour is completely cooked and the correct final moisture achieved.

Modern methods of cooking starch/sugar slurries employ heat exchangers, which give complete gelatinization with a lower proportion of water. The licorice produced may be poured onto tables and cut or extruded and in some cases it is dried off further in a hot room.

Licorice production, in its various forms, is specialized in certain companies and there are very many processes and formulations.

The plastic nature of licorice confectionery lends itself to the manufacture of tubes, strips, and other shapes particular to children's lines. Jackson (1973) gives more detailed description of these products.

CHOCOLATE AND CONFECTIONERY SPREADS— CHOCOLATE SYRUPS

These spreads may be considered confectionery or bakery products. The composition and processes are closely associated with confectionery but the uses are almost always related to cakes, sponges, and bread, and occasionally drinks.

Chocolate spreads became popular during World War II and in the immediate postwar period when there were still food shortages in Europe.

Water-Based Spreads

The most popular were those made from cocoa powder dispersed in a syrup of sugar, invert sugar, and sometimes glucose syrup. The composition of these spreads is similar today.

The proportion of cocoa powder is usually between 18 and 22 percent, and is low fat (10 to 12 percent cocoa butter). The concentration of the syrup is important and ranges between 75 and 77 percent—syrups below 75 percent are vulnerable to microbiologi-

cal attack. High-concentration syrups are too viscous for spreading and the same applies if the cocoa content is increased.

The syrup phase concentration depends on the proportion of invert and glucose syrup in the mixed syrup.

Natural cocoas are normally used in these spreads but alkalinized cocoas may also be included to give darker or redder shades. Occasionally, light-colored cocoas derived from Criollo beans are used.

Manufacture of these spreads is a simple process.

The cocoa powder is placed in a low-pressure steam, stainless-steel pan with contrarotating scraper paddles, and a small amount of syrup added. This mixture is run out to a smooth stiff paste at a temperature not exceeding 49°C (120°F). The remainder of the syrup is added slowly until the cocoa paste is dispersed completely. It is general, though not essential, to heat the mixture to 180 to 190°F to sterilize and develop flavor, but if this is done, some moisture loss will occur and this must be allowed for in the recipe. The heating time must also be strictly controlled. It is usual to add flavors such as vanilla at the end of the process. The mixture is cooled to about 43°C (110°F) and deposited into waxed cartons with screw top lids, which allows a certain amount of ventilation. If jars with sealed lids are used, these should be sterilized or there is a risk of mold growth.

In some spread recipes, modified starch, alginates, or low methoxyl pectin are added, usually in conjunction with a reduced cocoa content. These tend to produce a paste rather than a viscous syrup—they may spread better, but lack flavor.

Milk chocolate spreads may be manufactured by including milk powder as partial replacement for the cocoa. Nonfat powders are preferable as the inclusion of milk fat in a water-based spread may lead to rancidity or other off-flavors.

Fat-Based Spreads

Fat-based spreads may be made where the continuous syrup phase in the water-based spreads is replaced by a soft vegetable fat.

The fat must have properties that give good spreading qualities at normal temperatures. It must not show oiling out or separation of the liquid fractions and there must be no shrinkage due to excessive solidification of the higher melting components.

The most successful fatty spreads of recent years have been those containing nut ingredients. All nuts contain natural oils and those

most applicable to spreads have the following approximate contents:

Hazelnuts	64 percent
Almonds	55 percent
Peanuts	45 percent

Probably the original nut spread would be peanut butter, which is consumed in vast quantities in the United States.

The product made from the nut alone is subject to oil separation. Physical modification of the oil has resulted in a more stable material suitable as a spread for crackers, and cakes and as a filling for confectionery items.

Hazelnut/cocoa spread has become very popular and proprietary brands on the market now sell very well. Fatty spreads are also manufactured using milk powder, without nuts or cocoa, and with cocoa powder alone.

According to Heemskerk (1981), the following compositions of fatty spreads are representative (Table 19.8). The fat ingredient is mostly responsible for the properties of the final spread and must consist of:

1. A liquid oil stabilized by the inclusion of a small percentage of a high melting component; or
2. A natural or tailor-made oil, which has the appropriate stabilizing fractions so that it has satisfactory physical properties under ambient temperatures.

Manufacture of Fatty Spreads

In some respects, processing resembles that applied to chocolate or compound coatings. The solid ingredients are mixed with a propor-

TABLE 19.8. COMPOSITION OF FATTY SPREADS

Ingredient	Type of spread		
	Nut	Milk	Cocoa or chocolate
Fats %	25-40	30-40	30-40
Nuts %	5-15	—	—
Cocoa powder %	5-10	—	10-18
Milk solids %	0-10	18-25	0-5
Sugars %	40-55	40-55	40-55
Lecithin %	0.3-0.6	0.4-0.6	0.3-0.6
Flavor	as required	as required	as required

Source: Heemskerk (1981), Friwessa Zaandam, Holland.

tion of the fat to give a paste of consistency suitable for roll refining. After refining, the remainder of the fat is added and the mixture conched or otherwise suitably mixed to give a smooth paste. The nuts are normally blanched and roasted to a degree sufficient to enhance the nutty flavor.

Other mills, such as the Stephan or MacIntyre, may be used, when all the ingredients are charged in at the outset of processing. These machines are described in other parts of the book.

Chocolate Syrups

These are basically similar to syrup spreads with a much higher water content. Consequently, they are sold in sterile cans or jars. Superfine cocoa is used and stabilizers are usually added to prevent separation on storage.

RECLAIMING OF CHOCOLATE AND CONFECTIONERY "SCRAP" (REWORK)

In all manufacturing processes, material is produced that cannot be included as part of the final article for sale. Food, including chocolate and confectionery, is no exception.

In mass production food processes, particularly those involving cutting and stamping, offcuts are produced in considerable quantity. This material is quite wholesome and should be returned to a previous stage in the process in a constant proportion so that the quality of the saleable product does not suffer in any way.

Psychology plays a part in the handling of this material. If it is consigned to containers, even temporarily, which are in poor condition, dented, with ill-fitting lids, or perhaps dirty, the contents are immediately downgraded in the eyes of the workers. In the worst circumstances, other trash will be deposited on what is a perfectly edible product.

Assuming care is taken, reincorporation of substances such as chocolate bars, cooky dough, or marzipan is merely a process of blending with new production in a suitable mixer.

When it comes to chocolate-covered confectionery, aerated products, high boilings, and highly flavored and colored creams, the problem becomes more complicated and special processes have to be used.

The word "scrap" is now considered a bad description and the same translated into other languages implies material that is waste,

unwholesome, and not suitable for consumption. The EEC directive states that the word "rework" should be used and this causes no problems with translation.

However, in this chapter the word "scrap" is perpetuated. By some reclaiming methods, a good-quality material is obtained by filtering and decolorizing a product that otherwise would be unfit for reincorporation direct.

Foreign Matter, Sanitation

As suggested above, the handling of scrap will involve a risk of contamination with foreign matter or microorganisms however well operators are trained in sanitation.

Some publications recommend segregation of different types of scrap so that each can be returned to its appropriate formulation. Experience has shown that this procedure is generally unworkable unless there is a very small number of products.

The following methods of reclaimation have been proved and should be followed by all companies concerned with good manufacturing practice and quality control.

All processes that do not allow for an immediate return of scrap to manufacture should include filtration or screening and sterilization by heating.

In the chapter on "Hygiene," various devices for foreign matter prevention for inclusion in standard equipment and processes are described and some of these are applicable to reclaiming also.

Reclaiming of Scrap as Syrup

Confectionery fondant centers, hard candy, aerated confections, and jellies that are not chocolate covered can be returned to any process as a basic raw material if converted to a colorless, flavorless neutral syrup.

The basic process of reclaiming as syrup consists of dissolving the scrap in water, screening to remove foreign matter and pieces of nut and fruit, adjusting pH, and then adding decolorizing carbon and filtering. With fondants this a straightforward procedure but if the scrap contains egg albumen, other whipping agents, or fruit pulp, a modified procedure is necessary to aid filtration. With some confections such as acid-flavored hard candies, fruit-filled fondants, or fruit jellies, the proportion of invert sugar present or formed in the reclaiming process is considerable and it is preferable to convert the

scrap to an invert syrup that contains invert sugar and any glucose syrup in the original recipe, but no sucrose. This syrup can be used in the original recipe to replace invert sugar and, if necessary, the glucose can also be allowed for but this usually can be ignored if the reclaim syrup used is not more than 10 percent of the basic recipe.

Enzyme Filter Aids

Protein matter, particularly egg albumen, is a great nuisance in causing syrup foaming and retarding filtration in the reclaiming process.

Trypsin and pepsin (peptide peptido-hydrolyases) can help considerably in making a syrup filterable, and the choice depends on whether acid or alkaline conditions are most suitable for the process. The optimum conditions for trypsin are pH 8.5 at 40 to 46°C (104 to 115°F) but good results can be obtained at pH 7.5 to 8.0 over a period of 48 hr at the temperatures quoted, with a 50 percent syrup concentration. The lower pH reduces alkaline caramelization, which can be serious at pH 8.5. With pepsin, a low pH is required (1.8 to 2.0), and in a syrup of 50 percent concentration at 40 to 46°C (104 to 115°F) a digestion period of 48 hr should break down all protein matter. This latter process is preferable provided inverted syrups are required. A check on the end point of digestion in both cases can be made by adjusting a sample of the syrup to pH 5.0, adding 1 percent activated carbon, filtering, and the filtered syrup subjected to gentle boiling. No persistent foam should be produced, and the test filtration should have taken place without clogging of the filter paper. When protein has been removed, the batch of syrup is neutralized, active carbon added, and filtered.

Pectinaceous material causes filtration difficulties, particularly if the proportion of jam confections is high. Pectin enzymes are a useful aid. The natural enzymes that degrade the various forms of pectin in fruit pulps and juices are essentially pectinesterases and polygalacturonases but when it is necessary to assist the removal of pectin, pectolytic enzymes produced synthetically by the action of molds are used. Commercial pectinase preparations vary appreciably and the efficiency depends upon the exact nature of the enzymes present. For reclaiming scrap, the commercial preparation has a high polygalacturonase content and some pectin methyl esterase activity. Pectin methyl esterase hydrolyzes the methyl ester groups in pectin giving low methoxyl pectin. Pectin polygalacturonase hydrolyzes the 1,4 glycosidic link in the polygalacturonic acid molecule with the forma-

tion of polygalacturonic acids of lower molecular weight and some galacturonic acid. Activity is greatest in the normal pH range for fruit (3.3 to 5.0) at temperatures of 57 to 63°C (135 to 145°F) and 30 to 60 min are required for completion of pectin degradation in a 50 percent syrup. The quantity of enzyme required depends on the fruit substance present and can be found by experiment and reference to

Enzyme application has made many advances in recent years and specific enzymes that work in near-neutral solutions are now available for the treatment of scrap containing starch, gelatin and pectin.

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Invert Syrups—Use of Invertase Enzyme

The traditional method for the manufacture of invert sugar from pure sugar (see "Invert Sugar") is by acid hydrolysis, and with pure sucrose the quantity of acid required is quite small. When invert syrups are made from scrap confectionery, inversion by acid is greatly retarded by the presence of small amounts of mineral salts, and the use of invertase is preferable because it avoids excessive amounts of inverting acid. The technologist will require to work out the optimum conditions for dealing with a particular type of scrap and the effects of concentration, pH, and temperature are given in the sections on "Invertase" and "Invert Sugar." The economics of using syrups of higher or lower concentration depends on how the scrap is dissolved or used after inversion. Similarly, the actual quantity of invertase used in relation to the time of inversion needs careful costing. Equipment for the inversion of syrups must be designed to have thermostatic control, adequate mechanical stirring to prevent local overheating, and automatic pH control. After inversion, the syrup must be heated to inactivate the enzyme; this usually occurs automatically when the syrup is used in subsequent processes or during concentration.

Process and Equipment

Process and Equipment

The equipment for reclaiming scrap as syrup need not be complicated or expensive, but economies can be realized by installing

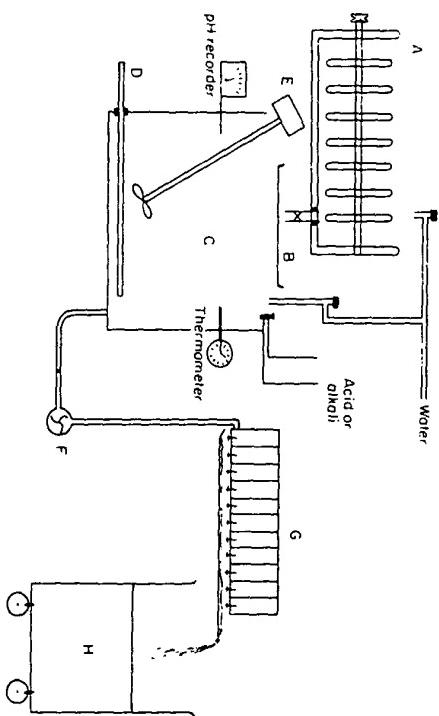


Fig. 19.38. Diagram of Plant for Reclaiming Scrap

ancillary equipment for hoisting drums of scrap and for pumping the reclaimed syrup. A diagram of the type of equipment that has been used for many years is given in Fig. 19-38.

(A) is a non-rotating steam-jacketed mixer with rotating paddles. Water is added to the mixer to a predetermined level followed by a weighed quantity of scrap. Since the scrap may be in large drums, a hoist is necessary and a steam jet will assist in obtaining complete discharge. Steam is applied to the jacket, the mixer set in motion, and when the scrap is dissolved, the syrup should have a concentration of 50 to 55 percent, which is checked by refractometer.

The hot syrup is then discharged to tank (C) through a fine mesh sieve (B) that removes foreign matter, pieces of nut, fruit, and other solids. When the tank is full, the pH is adjusted to 5.0 after the mixer (E) has been set in motion and the concentration adjusted to 50 percent. If enzyme treatment is necessary, acid or alkali is added to obtain the pH appropriate for the enzyme being employed, but after enzyme treatment the pH is readjusted to 5.0.

When the enzyme treatment (if necessary) is completed and the pH adjusted, decolorization is obtained by the addition of powdered active carbon; there are various brands on the market.

The quantity required depends on the amount of color to be removed and is usually between 0.5 percent and 1.0 percent of the syrup by weight, but the most economical and effective quantity can be determined by experiment.

There is also some latitude allowable in the temperature of the syrup at the decolorizing stage and this usually varies between 49°C (120°F) and 71°C (160°F), the optimum temperature being found by experiment for any particular mixture of scrap. At the higher temperatures, decolorization will occur more rapidly and at all temperatures the reaction should be complete in 15 to 30 min but a check on a filtered sample of the suspension will show how the process is proceeding. The syrup with the carbon is then pumped (F) to the filter press (G) and the clear syrup collected in the trolley tank (H). Filtration is greatly assisted by mixing a filter aid with the carbon in the decolorizing tank in a quantity equal to the amount of carbon.

Filter aids are diatomaceous earths, and to effect an economy they may be mixed with a proportion of pumice powder.

Sometimes these filter aids are suspended in water or clear syrup and pumped to the filter press so that a bed of filtering material is laid down on the filter pads before the carbon suspension is filtered.

An alternative procedure is to add the majority of the filter aid with the carbon in the first batch of syrup pumped to the clean press. Subsequent batches of syrup will require much smaller quantities of filter aid until the press chambers have become filled. The same also applies to the quantity of decolorizing carbon required, because the layer of carbon in the press still retains a lot of its decolorizing power.

Some syrups containing caramelized sugar, or high boiled sugars that have been aerated with sodium bicarbonate, are difficult to decolorize completely without using large quantities of active carbon. In such cases, it is possible to use the double decolorizing principle. This makes use of the carbon/filter aid paste discharged from the filter press for the first syrup treatment and the filtered syrup from this first treatment receives a second decolorizing with new carbon. A somewhat different arrangement from that shown, with extra treatment tanks, is required for this process and the economics of extra decolorizing must be studied closely.

When sodium bicarbonate has been used in a confectionery product, much effervescence will take place when acid is added for

neutralization or pH adjustment and it is very important then to ensure that an unmanageable foam is not produced. Enzyme treatment or the addition of antifoam will help and a small amount of fat addition is usually effective for this purpose. Laboratory experimentation before adopting a reclaiming process on a commercial scale must be emphasized. The type of scrap, whether it is to be pulverized, and how it shall be dissolved can all be worked out on a small scale and the economics studied.

Scrap Containing Fat

Caramel, fudge, nougat, and other confectionery containing a high proportion of fat are not satisfactorily treated by the above method as the fat will partially separate and cause embarrassing scums on the surface of the tanks. In such cases two methods can be adopted: (1) The syrup at 50 percent concentration is heated and allowed to stand in tanks or drums until fat has risen to the surface, when it is skimmed off. This process is costly because of the handling and loss of fat, as reuse of this fat is not recommended after this treatment and it can only be sold for refining. (2) The caramel or other material is dissolved hot at about 60 percent concentration, screened, and instead of going through the decolorizing process, is used in this form as a base ingredient for certain specific recipes of the caramel and fudge type. This process should apply only to fresh scrap.

It is possible to dissolve solid scrap in a new boiling of caramel but screening to remove foreign matter is more difficult in a finished boiling and it is not easily applicable to a continuous boiling process.

The Use of Reclaimed Syrup

The decolorized syrup must be used within two or three days as it will not keep at 50 percent concentration, and where there is large fondant creme manufacture, this presents no problem.

The process can be operated at 60 percent concentration but decolorizing and filtration are more difficult. Normally, the filtered decolorized syrup will have a pH somewhat higher than 5.0 and can be used without further neutralization for most confectionery if the proportions are not too high. If the syrup is to be stored, it is much better to convert it to an invert syrup and concentrate to 75 to 78 percent, and to do this the filtered decolorized syrup is treated with invertase enzyme in thermostatically controlled tanks followed by vacuum concentration. This is described under "Invert Sugar."

Reclaiming Chocolate-Covered Scrap

The return of chocolate-covered confectionery scrap to the original product can be brought about by several methods but some manufacturers of high-quality products prefer to make a separate line from the scrap and sell this through cheap stores or markets under a name that does not identify the origin. This is not a profitable method as a rule.

The types of line that will accept a variety of scrap in the confectionery center are limited and usually they are confined to caramels, fudges, pastes, and dark-colored nougats or nougatines. It is better from a quality standpoint and more economical to return the processed scrap to the chocolate if legislation permits.

Reclaiming of Scrap as Refiner Paste

Chocolate-covered cremes and confectionery units are reduced to a paste in a warm melangeur or edge runner with the addition of either fine sugar, chocolate refiner paste, or cocoa butter, or a combination of these, depending on the nature of the confectionery scrap. This process removes most of the moisture in the confectionery centers, and pulverizes any nut or similar ingredient as well as ensuring a good mixing. This paste is then put through a roll refiner. This refined paste can be mixed with a confectionery center base where light colors are not required or added to chocolate in quantities not exceeding 5 percent. In this proportion, the presence of small amounts of other sugars (invert, glucose), and perhaps foreign oils and fats, will have negligible effect on chocolate viscosity, flavor, or other properties.

But this process has two failings: (1) it does not take into account foreign matter that may be present, and can even grind it into the paste; and (2) it does not sterilize the scrap.

Since most of this foreign matter is likely to be metallic, this can be mostly removed after passing the scrap through an electronic metal detector before the melangeur process.

It is always possible that microorganisms will contaminate the paste. Although they will not propagate, they will certainly not be destroyed by the low process temperature. Subsequently, if the paste is incorporated in a higher-moisture confection, they may become active.

Reclaiming of Scrap as "Crumb"

A method that has been used very successfully employs the milk crumb process described under "Chocolate" and this has distinct advantages over the paste process because it:

1. Removes foreign matter.
2. Sterilizes the scrap.
3. Removes the majority of flavors by steam distillation.

This process is available to those manufacturers who make their own milk crumb by the vacuum process. It is expensive to install equipment specially for this method of reclaiming but some factories have done so.

The principle of the process is to replace the fat-free cocoa content of some of the liquor used in the crumb process by the fat-free cocoa present in the scrap. The sugars in the scrap (calculated as sucrose) similarly replace some of the sugar in the crumb recipe. By this process a crumb can be produced that contains as much as 15 to 20 percent of chocolate-covered scrap and in the chocolate-making process may be blended with crumb containing no scrap so that the finished chocolate contains a maximum of 5 percent.

Process

In the manufacture of milk crumb, the milk is first evaporated to about 37 percent total solids and the sugar is then added, followed by condensation. A weighed quantity of scrap that is calculated to replace certain quantities of liquor and sugar in the crumb batch is dispersed with water in a separate kettle, raised quickly to the boil, and this slurry is then sucked or pumped through a fine-mesh screen to the condensing kettle. Condensing proceeds as for normal crumb and the volatile flavors are removed with the evaporated steam. Foreign matter, nuts, and other solids are extracted on the screen and the preboiling and condensation are sufficient to destroy all microorganisms. The crumb process then proceeds normally through the condensing, kneading, and drying stages and a crumb is produced that is practically indistinguishable from that made without scrap. It is sterile, has good keeping properties with very little variation in composition, and can be used without difficulty in the normal milk chocolate manufacturing process.

A similar process can be adopted without the milk ingredient and a

dark crumb is produced that can be used in dark chocolate manufacture.

In this method of reclaiming, some sorting of the constituents of the scrap is desirable, for example, milk-chocolate and dark-chocolate-covered cremes should be kept separate or blended together in some definite proportion so that the fat-free cocoa content is known. Filled blocks or cremes made on shell equipment usually have a higher chocolate content and these are best kept separate from enrober covered chocolates. By attention to these points, it is possible to make a crumb with very constant composition.

It is surprising how effectively flavors are removed in this process, including peppermint, which by other reclaiming methods is impossible to eliminate and necessitates its use only in peppermint confectionery.

Some flavors are not removed and these include caramelized sugar, but because some caramelization takes place in the crumb process itself this extra flavor may be tolerated to a limited extent. A few synthetic flavors are not volatile in steam and tests can be made to prove this. In many cases, a volatile flavor equally good and not fugitive in the confectionery product can be found.

Legislation

Some countries that have strict laws regarding chocolate composition do not permit the return of rework as an ingredient of the chocolate but insist that it must be used only in centers. It is regarded as an adulterant of chocolate, which must be made from pure cocoa nib, sugar, and, if milk chocolate, milk solids in addition.

While there may be some reason for such argument in the case of solid chocolate bars or blocks, it is difficult to substantiate if the chocolate is mixed with nuts, raisins, cookies, or cereals, or is used as a covering for various confectionery centers.

This is a useful cost saving by the inclusion of rework and quality control checks have shown that no deterioration is detectable when rework not exceeding 5 percent is incorporated and the chocolate used for covering or recipe mixtures.

MULTIPLE CONFECTIONERY BARS

Many confectionery bars have appeared on the market that consist of layers of different types of product in contact with one another. Many of these are attractive but often the nontechnical members of a

company are unaware of the limitations that must be placed on the combinations that may be used. Many skilled sugar confectioners also are not at all sure of permissible combinations and lack of knowledge of the theory behind the problem can lead to very unsatisfactory shelf life in the end product.

The shelf life of a multiple confection is related to the equilibrium relative humidity (ERH) and its significance are explained in several sections of the book.

Confectionery products with similar ERH may be placed in contact without significant moisture transfer. If there is a wide difference, then moisture will transfer from the confection with the high ERH to that with the lower. In the worst cases, this can have disastrous effects on quality and shelf life. The following examples, which were actually suggested by a marketing organization, illustrate what might happen.

1. Wafer cookies are layered with fondant creme. After a short period of storage, the wafers became sodden and tough. The creme became dry and short. Wafers have an ERH of about 20 percent and fondant creme about 70 percent.
2. A honeycombed boiled sugar is layered with a soft jelly. The high ERH jelly will transfer moisture to the boiled sugar. The honeycomb structure will collapse completely to a syrup. If it was a chocolate-covered bar, it would become hollow. Boiled sugar has an ERH of about 25 percent, and the jelly, 70 percent.

The equilibrium humidity of a confection is controlled primarily by the concentration of the syrup phase, and to a lesser extent by its composition. Sucrose crystals in fondants and fudges, and fat in fudges and caramels, play no active part. The higher the syrup concentration, the lower is the equilibrium humidity and the more hygroscopic the confection. The proportion of each confection must also be considered in relation to moisture transfer, and sometimes the transfer of moisture from one layer to another does not detract from the quality of the whole bar. An example is a thin layer of caramel on top of a bar of soft nougat. The nougat will have an ERH of about 65 percent and the caramel 50 to 55 percent. Moisture will transfer from the nougat to the caramel, raising the ERH and making the caramel softer. Moisture will be lost by the nougat but because of the small proportion of caramel layer, the amount of moisture lost by the nougat is small and its texture is not changed significantly. If,

however, the proportions of caramel to nougat were equal, it is likely that the caramel would become liquid and the nougat hard.

The low equilibrium humidity type of confection is generally brittle or hard (butterscotch, hard candy), whereas the medium ERH type is chewy (caramel, nougat). The higher ERH type contains crystals (fudges and fondants), or may be noncrystalline but high in moisture (jellies, Turkish delight).

Moisture content alone, therefore is not a reliable guide to the ERH but an increase in moisture in any type of confection will raise the ERH and vice versa.

A list of the ERH values of various confections is given in other sections of the book.

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Nuts and cereals (e.g., corn flakes, rice krispies) must be used in combination with confections of low equilibrium humidity or they lose crispness and are more prone to flavor deterioration. Nuts can tolerate a higher humidity than cereals, but when the nuts are roasted, a low-humidity confection is desirable.

Cookies are similar to cereals and should be combined with low ERH confections although some fatty-type cookies can be combined with some of the medium ERH type without becoming objectionably soft.

Dried fruits, such as raisins or preserved peels, are sometimes mixed with low-moisture confections. This leads to the transfer of moisture from the fruit pieces to the confection. In some instances, the fruit pieces become objectionably hard.

Insulating Layers

In some instances, a fatty layer will provide a barrier to retard, if not prevent, moisture transfer. The effectiveness of this barrier will depend on its continuity, thickness, type of fat, and probably the presence of other materials, such as sugar or milk powder in the fatty layer.

There is some evidence to suggest that a high-melting-point fat is more effective than one of low melting point, although there are obviously limits on the score of palatability.